European Journal of Ecology, 2024, 1-4

PROGRESS IN SHRIKE RESEARCH: GLOBAL TRENDS, CHALLENGES, AND NEW DIRECTIONS

Reuven Yosef[1] and Piotr Tryjanowski[2]

[1]*Ben Gurion University of the Negev, Eilat Campus, P. O. Box 272, Eilat 8810201, Israel*
(ryosef60@gmail.com)
[2]*Department of Zoology, Poznań University of Life Sciences, Wojska Polskiego 71C, 60-625 Poznań, Poland*

Abstract.

Over the past 30 years, research on shrikes has made significant strides, driven by technological advancements, long-term ecological studies, and an increasing focus on conservation. Shrikes (Laniidae), a fascinating group of passerines with predatory behaviors, are studied globally; however, research remains heavily concentrated on a limited number of species in Europe, North America, and Asia. Despite growing interest, critical gaps persist in understanding the ecology and behavior of lesser-known species, particularly in Africa and Asia. This symposium brings together global experts to share insights from long-term monitoring, examine the impact of climate change, and showcase cutting-edge methodologies such as geolocation and genomics. By addressing both emerging trends and challenges in shrike conservation, this symposium paves the way for new directions in avian research, offering a comprehensive vision for the future of shrike studies.

Key words: *avian conservation; behavioral adaptations; climate change impact; long-term monitoring*

The intriguing Shrikes

Shrikes (Laniidae) are a fascinating group of passerine birds, exhibiting behaviors reminiscent of birds of prey. They have captivated researchers for decades, leading to the establishment of the International Shrike Working Group (ISWG) to enhance collaboration among those studying this unique group. This initiative formalized efforts to connect researchers, share literature, and organize symposia. The first symposium was held in Florida in 1993, followed by meetings in Israel (1996), Gdańsk (1999), and Chemnitz (2003). After a prolonged gap, partly due to the COVID-19 pandemic, the 5th International Shrike Symposium was finally held in Porto, Portugal, in July 2023, marking the 30th anniversary of the ISWG's founding.

The 2023 symposium was more than a research-sharing event; it was a testament to the resilience of the shrike research community. Despite the loss of valued colleagues, including influential figures like Tom Cade, Viking Olsson, Hans Esselink, Tony Harris, and most recently Eugeny Panov (Panov, 2011), the field continues to attract new generations of researchers. These younger scientists bring fresh methodologies and advanced technologies, breathing new life into shrike research. This continuous influx of talent ensures that the field remains dynamic and innovative.

Fig. 1. The conference logo artwork was created by renowned French graphic artist and watercolorist Alexis Nouailhat. Sadly, Alexis passed away in January 2022 at the age of 55, just before the symposium took place. A collection of his watercolors, illustrations, and postcards can be viewed at: http://alexis-nouailhat.com/.

Significant progress in shrike research has been made in recent years, including the publication of two seminal books now considered cornerstones in the field: Panov's *The True Shrikes of the World* (2011) and the second edition of Lefranc's *Shrikes of the World* (2022). Additionally, species accounts initially compiled by ISWG members and featured in the Handbook of the Birds of the World are now accessible on a digital platform hosted by the Cornell Lab of Ornithology (*Birds of the World*, 2022). This shift highlights the evolving nature of scientific research, where digital accessibility plays an increasingly important role in data sharing and collaboration. Furthermore, the international shrike library, once a key resource in Israel, has been relocated to the World Center for Birds of Prey in Boise, Idaho. Although this move aimed to preserve important hard copies, the increasing reliance on digital resources has made the library less utilized than anticipated.

Long-term, integrative data was a recurring theme at the symposium. Many researchers, including those from Belgium, the Netherlands, and Austria, presented long-term studies—some spanning over 30 years—emphasizing the importance of continuous monitoring to understand the impacts of climate change, habitat alteration, and other anthropogenic factors on shrike populations. However, these studies are often limited to the edges of species' ranges, leaving large gaps in our understanding of global population trends, particularly in under-studied areas like Asia and Africa.

Migration studies also took center stage. New data on migration routes and wintering grounds, obtained through advanced tracking technologies such as geolocators, have offered fresh insights into the movements of several shrike species. This includes recently discovered migration patterns of the Lesser Grey Shrike (*Lanius minor*), whose population has been rapidly declining in Central Europe, as discussed by Anton Krištín and others (see below). Conservation remains a top priority, with numerous presentations addressing habitat restoration and public engagement efforts. In Italy, researchers used camera traps to gather detailed information on habitat use and feeding behavior. Meanwhile, in northern Italy and Spain, researchers are examining how plastic pollution affects nesting success, underscoring broader environmental challenges facing shrikes and many other species.

The symposium also touched on the cultural significance of shrikes. These birds have long been celebrated in art, from ancient Egyptian tomb paintings to modern postage stamps. Their symbolic value and ecological importance make them ideal for public engagement initiatives aimed at raising conservation awareness. In conclusion, the 5th International Shrike Symposium not only reflected on the rich history of shrike research but also highlighted the exciting directions the field is taking. With ongoing technological advances and an ever-growing community of dedicated researchers, the future of shrike studies is bright. As we look ahead, the challenge remains to expand research to include under-studied species and regions, integrating global perspectives to better understand and conserve these remarkable birds. The next symposium, anticipated to be held in Africa, will continue to foster collaboration and innovation in shrike research.

Standing on the Shoulders of Giants

Modern shrike research is deeply rooted in the foundational work of pioneers whose dedication and creativity have shaped the field. The advancements in our understanding of these remarkable birds owe much to the legacy of these giants, whose innovative approaches continue to inspire new generations of scientists and artists. This issue of the *European Journal of Ecology* pays tribute to two such individuals—Evgeniy Panov and Alexis Nouailhat—whose contributions have profoundly influenced the study and appreciation of shrikes. In recent years, the shrike research community has faced the profound loss of these two pivotal figures. Evgeniy Panov, a brilliant scientist and a pioneer in the behavioral ecology of shrikes, dedicated his career to unraveling the intricacies of their lives. His groundbreaking research and publications set a benchmark in ornithology, providing invaluable insights into the complex interactions and adaptations of these birds. Alexis Nouailhat, in contrast, brought shrikes to life through his artistry, capturing their beauty and essence in a way that science alone could not convey. His unique perspective illuminated the emotional and aesthetic dimensions of nature, inspiring a broader audience to appreciate and protect these birds. Nouailhat's work fostered a deeper emotional connection to conservation, blending art with advocacy in a way that resonates profoundly in a time of increasing environmental challenges. Together, Panov and Nouailhat exemplify the powerful synergy of science and art. Their legacies are a testament to the diverse ways in which human creativity and intellect can enhance our understanding of the natural world. As shrike research continues to evolve, their vision and contributions form the bedrock upon which future discoveries will be made. This harmonious integration of meticulous scientific study and evocative artistic expression reminds us that today's progress is built on the efforts of those who came before. Panov and Nouailhat's enduring influence serves not only as an inspiration but also as a call to continue bridging the gap between disciplines, enriching our collective understanding of nature and deepening our commitment to its preservation.

Ongoing Progress

At one point, it seemed research on shrikes might have reached a peak, with the group's challenging field study conditions limiting new insights. However, recent studies—many of which were presented at the symposium—show that this is far from the case. New research continues to push the boundaries of what we know about shrikes, underscoring the dynamic and evolving nature of this field.

Since the symposium, several notable studies have been published. One groundbreaking study by Adamík et al. (2024) examined the migration patterns of the Lesser Grey Shrike, providing valuable data on non-breeding sites and annual migration cycles. Utilizing advanced tracking technology, this research offered unprecedented insights into migration routes and stopover sites. Another study by Tryjanowski et al. (2024) explored interactions between the red-backed shrike (*L. collurio*) and the common cuckoo (*Cuculus canorus*), examining how brood parasitism influences shrike settlement patterns. Their findings point to the complexity of host-parasite interactions and suggest that human presence and nest predation may also influence territory selection. Meanwhile, Kwieciński et al. (2024)

focused on the impact of plastic pollution on shrike nesting behavior, revealing startling levels of contamination in farmland environments. This research emphasizes the importance of understanding the broader ecological context in which shrikes operate, particularly as human-induced environmental changes reshape natural habitats.

In addition to these studies, other recent research has further enriched our understanding of shrike biology. For example, a study by Peña-Peniche et al. (2023) documented the Loggerhead Shrike (*L. ludovicianus*) hunting scaled quails—prey significantly larger than itself. This documentation of "big game hunting" underscores the shrike's dietary versatility and highlights the need to understand predator-prey interactions across different environmental contexts. Hill et al. (2023) also made a compelling contribution with their research on adoption behavior in Loggerhead Shrikes. Their findings suggest that unpaired males may adopt unrelated young as a reproductive strategy in populations with a skewed sex ratio, presenting a fascinating evolutionary explanation for this costly behavior.

In the realm of biomechanics, Sustaita and Laurin (2024) investigated the functional anatomy of Loggerhead Shrikes' jaw-closing mechanics, highlighting how these birds manage diverse prey. Their findings reveal a balance between force and speed in the shrike's bite, illustrating the importance of biomechanics in understanding predatory efficiency.

Genetic studies have also yielded new insights. McCullough et al. (2023) examined ultra conserved elements in shrikes and their relatives, proposing the new avian family Eurocephalidae for the white-crowned shrikes (Eurocephalus). This genetic re-evaluation redefines our taxonomic understanding and underscores the need for continued molecular research (see Fuchs et al., 2019). Meanwhile, Muhammad et al. (2024) used mitochondrial DNA analysis to assess genetic variation and population differentiation among four shrike species in Pakistan, providing critical data for conservation efforts aimed at preserving genetic diversity.

On the topic of species interactions, Mizumura et al. (2024) studied hybridization between the endangered brown shrike (*L. cristatus*) and the common bull-headed shrike (*L. bucephalus*) in Japan, discovering that hybrid individuals are fertile. This finding raises concerns about gene flow and the conservation implications for the brown shrike's genetic integrity.

Jarrett et al. (2024) used DNA analyses and metabarcoding to reveal the dietary habits of migratory shrikes by analyzing their fecal samples. The researchers successfully showed how Woodchat Shrikes (*L. senator*) stopping over in Morocco in spring, while returning north from their wintering grounds in Africa, consumed blood-swollen camel-ticks (*Hyalomma dromedarii*). This study raises interesting questions about how shrikes access protein-rich prey while on migration and how many other such strategies have yet to be discovered with the help of ever-improving modern technology. Cortés-Fossati and Rojo (2023) also provided valuable insights with their study on shrike predation of toxic blister beetles, showing selective feeding strategies that enable shrikes to avoid the more toxic parts. This research contributes to our understanding of shrikes' complex foraging strategies and their role in controlling pest species.

Collectively, these studies highlight the ongoing vibrancy of shrike research, spanning behavioral ecology, biomechanics, genetics, and conservation. The field is thriving, and the integration of novel technologies and cross-disciplinary collaborations continues to drive new discoveries.

Acknowledgments

Our deepest gratitude to Professors Luis Reino and Joanna Santana, whose efforts made the 5th International Shrike Symposium in Portugal an enriching and successful event; supported by the BIOPOLIS-CIBIO - University of Porto at Vairão, Vila do Conde, Portugal, they navigated logistical challenges to create a hybrid format, allowing remote participation for international researchers. The Scientific Committee, comprising Dries van Nieuwenhuyse (Belgium), Prof. Piotr Tryjanowski (Poland), Dr. Boris Nikolov (Bulgaria), Norbert Lefranc (France), Amy Chabot (Canada), and Prof. Reuven Yosef (Israel), played a crucial role in shaping the program.

We also extend heartfelt thanks to those involved in producing these proceedings, especially Professor Jakub Z. Kosicki, who accepted the proceedings as a special issue of the European Journal of Ecology. Special thanks go to the reviewers, including Norbert Lefranc, Dries van Nieuwenhuyse, Boris Nikolov, Susan Craig, Piotr Tryjanowski, Luis Reino, and Ursula Bryson, whose expertise was invaluable in ensuring the quality and success of the symposium and its publications.

References

Adamík, P., Wong, J. B., Hahn, S., & Krištín, A. (2024). Non-breeding sites, loop migration and flight activity patterns over the annual cycle in the Lesser Grey Shrike *Lanius minor* from a north-western edge of its range. *Journal of Ornithology*, *165*(1), 247-256.

Cortés-Fossati, F., & Rojo, M. (2023). When Toxicity is Not Enough: Review and New Data on Blister Beetle (Coleoptera, Meloidae) Predation by Shrikes. *Acta Ornithologica*, *57*(2), 197-202.

Fuchs, J., Alström, P., Yosef, R., & Olsson, U. (2019). Miocene diversification of an open-habitat predatorial passerine radiation, the shrikes (Aves: Passeriformes: Laniidae). *Zoologica Scripta*, *48*(5), 571-588.

Golawski, A. (2024). Red-Backed Shrikes "Help" in Studies of the Expansion of the European mantis. *Entomological News*, *131*(1). 131(1) : 53-55

Hill, C. E., Miles, K. R., Maddox, K. A., & Tegeler, A. (2023). Are adoptions in a predatory songbird a strategy to aid mate acquisition?. *Journal of Field Ornithology*, *94*(2).

Jarrett, C., Illa, M., Burri, M., Marcacci, G., Mata, V.A., Boglino, M.L., Himmi, O., Maggini, I. and Helm, B., (2024). 'Vampire birds': diet metabarcoding reveals that migrating Woodchat Shrikes *Lanius senator* consume engorged camel ticks in a desert stopover site. *Ostrich*, 1-5. https://doi.org/10.2989/00306525.2024.2386454

Kwieciński, Z., Gajzmer, M., Beszterda, M., Szala, K., Golawski, A., & Zduniak, P. (2024). Assessing plastic pollution in farmland: Impact of agricultural practices on bird nesting materials. *Ecotoxicology and Environmental Safety*, *285*, 117077.

Lefranc N. 2022. Shrikes of the World. Helm. London.

McCullough, J. M., Hruska, J. P., Oliveros, C. H., Moyle, R. G., & Andersen, M. J. (2023). Ultraconserved elements support the elevation of a new avian family, Eurocephalidae, the white-crowned shrikes. *Ornithology*, *140*(3), ukad025.

Mizumura, H., Kubota, K., Nishiumi, I., Imanishi, S., Mochizuki, M., & Higuchi, H. (2024). Hybridization and backcrossing between the endangered brown shrike (*Lanius cristatus superciliosus*) and the common bull-headed shrike (*L. bucephalus bucephalus*). *Biological Journal of the Linnean Society*, *142*(1), 81-90.

Muhammad, S., Imtiaz, A., Ruby, T., & Khan, A. A. (2024). Genetic variations and population differentiation in four species of shrikes based on mitochondrial (Mt) DNA cytochrome oxidase B gene. *Ciência Rural*, *54*(7), e20220553.

Panov, E. N. 2011. The True Shrikes (Laniidae) of the world – Ecology, Behavior and Evolution. Pensoft Publishers, Sofia. 910 pp.

Peña-Peniche, A., Canizales-Bañuelos, J. Á., & Ruvalcaba-Ortega, I. (2023). The Loggerhead Shrike (*Lanius ludovicianus*) goes big game hunting. *The Wilson Journal of Ornithology*, *135*(4), 589-593.

Sustaita, D., & Laurin, M. A. (2024). Biomechanics of biting in loggerhead shrikes: jaw-closing force, velocity and an argument for power. *Journal of Experimental Biology*, *227*(9), jeb246555.

Tryjanowski, P., Golawski, A., Jankowiak, Ł., Osiejuk, T. S., Kwieciński, Z., Møller, A. P., Grzywaczewski, G., & Jerzak, L. (2024). Do cuckoo calls affect red-backed shrike settlement pattern? An experimental approach. *The European Zoological Journal*, *91*(1), 550-558.

European Journal of Ecology, 2024, 5-6

TRIBUTE TO ALEXIS NOUAILHAT (1966-2021)

We can only say that the bird in our V^{th} conference logo looks happy. The sparkle in his eyes and a smile on his face show that he is happy with himself! Job well done: one prey just captured and another has already been impaled on a thorn. We can only pity the poor little creatures in the picture; one is still desperately fighting for survival, and the other seems to have already given up. The message is clear: a hooked bill passerine with a conspicuous Zorro mask can only be a shrike; a strong focus on a distinctive reddish cap reveals that it is a Woodchat Shrike, a species that captures small animals and maintains larders. As mentioned above, the cartoonist adds a distinct humorous side to reality. Pedagogy and humor go together very well.

This drawing is simply a feast for the eyes thanks to the talent of a unique artist: Alexis Nouailhat. His global work has rightly been called "*remède contre la morosité,*" a remedy for gloom! His brushstrokes are so skillful, and typical that everyone recognizes him immediately.

I had never met Alexis but knew his famous postcards well. When Luis Reino, the principal organizer of the 5th International Shrike Symposium planned in Portugal, suggested that we have a "*funny and appealing logo,"* Alexis's name immediately came to mind. An email sent to him in late October 2019 received a reply with this very happy-looking Woodchat less than a week later. It was, of course, unanimously accepted as our future logo.

Alexis had only one wish: he wanted us to make his work better known. As a tribute, we present some of his postcards.

Alexis traveled extensively throughout France, Europe, and the world. From the thousands of watercolors that were created in the field, around 100 (!) richly illus-

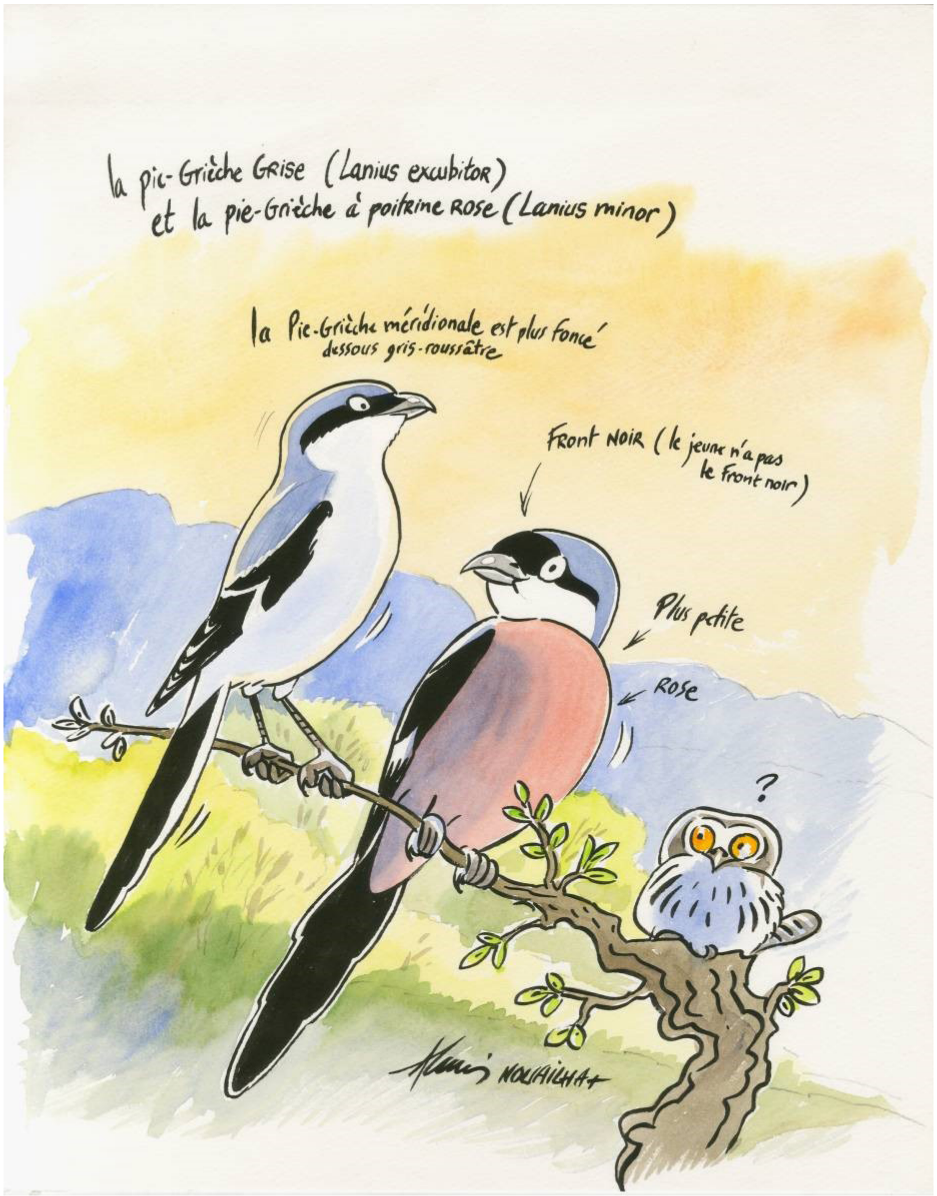
trated travel diaries ("carnets de voyage") were written. He had a fondness for wild mountain regions, as shown in his series of *Aquarelles* depicting the massifs of the Alpine system between the Mediterranean Sea and Slovenia. His first *carnet de voyage* on this system was *Le Massif des Ecrins*. He lived in a small village, at the foot of this Massif, a national park, a vast adventure playground! Amid vibrant wildlife, Alexis could observe the Bearded Vulture, one of his most-loved summit birds. It benefits from a fantastic watercolor publication: *Sur les ailes du Gypaète.*

Alexis's boundless love for nature and talent also enabled him to create almost 500 popular postcards, mainly dedicated to birds, mammals, and nature in general. He often put his paintbrush at the service of associative struggles and managed to convey his messages thanks to his humorous *Aquarelles.* For example, animals often considered undesirable, such as wolves, foxes, stoats, and birds of prey, become lovable animals in his work!

Alexis worked for numerous publishers and exhibited his watercolors in several salons in France and abroad. He left us far too early in May 2021, a great loss for those concerned with nature protection.

His website is still active: *alexis-nouailhat.com,* and his work is exhibited throughout the year in his former workshop, *l'Atelier du Gypaète* in Saint-Bonnet en Champsaur, in the Hautes-Alpes (south-eastern France).

Norbert Lefranc



European Journal of Ecology, 2024, 7-9

EVGENIY NIKOLAEVICH PANOV
3 AUGUST 1936 – 5 AUGUST 2024

Evgeniy N. Panov was a prominent Soviet/Russian scientist, widely recognized for his significant contributions in the field of ethology, zoology, and ornithology. A Professor and Doctor of Biological Sciences, he dedicated approximately 45 years of his career to the A. N. Severtsov Institute of Ecology and Evolution under the Russian Academy of Sciences. In 1993, he was awarded with the Russian Federation National Award for his groundbreaking studies on biosociality and communication in animals.

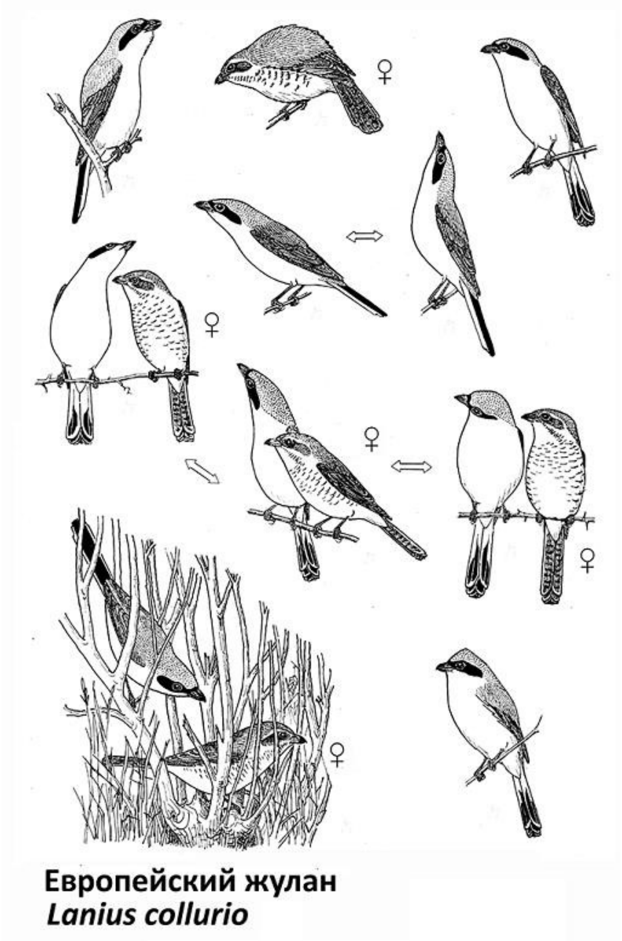
Evgeniy Panov was born in Moscow in 1936. He began his higher education in 1954 at the Faculty of Biology at Moscow State University, where he chose to specialize in vertebrate zoology. Over time, he developed a deep interest in ethology. For his Master’s degree, he conducted research on the ecology and behavior of Little Ringed Plovers in the Oka Nature Reserve. Following this, he continued his ethological studies on waders in the Russian Far East (for his field sketches see https://panov-ethology.ru/pictures). It was in the southern part of Primorsky Krai, specifically in the Kedrovaya Pad Nature Reserve, that his lifelong passion for shrikes began. His first publication on shrikes, in 1964, focused on the three species of shrikes (Brown, Tiger and Bull-headed Shrike) present in his study area.

Over the years, Evgeniy Panov undertook numerous expeditions to the Caucasus, Caspian Sea, and various regions of Central Asia, including deserts, steppes, and mountains. These expeditions led to a wealth of publications on comparative ethology, ecology, hybridization, bioacoustics, and more of wheatears, shrikes, gulls, and other bird species, as well as reptiles (mountain agamas), mammals, and even insects. Panov authored approximately 400 scientific publications, including over 20 books and monographs.

Among his notable works are books dedicated to shrikes, including “*Die Würger der Paläarktis*” (1983, 1996) and “*The True Shrikes (Laniidae) of the World. Ecology, Behavior, and Evolution*” (2008 – in Russian, 2011 – in English). His latest monograph on shrikes consolidates critical information on all 34 species of true shrikes occurring in Eurasia, Africa and North America. This comprehensive work covers evolutionary history, body size and plumage coloration, foraging behavior, breeding biology, ecology and distribution, signaling behavior and vocalizations, molt, and hybridization of closely related species. The book also addresses current molecular studies on shrikes.

In addition to being an exceptionally skilled observer and interpreter of bird behavior, Evgeniy Panov was also a talented artist. His high-quality, self-made drawings served as an invaluable tool in his studies. His artistic talent allowed him to illustrate many of his articles and books with professional level black-and-white sketches and drawings, enriching his scientific publications with visual representations of his observations.

Evgeniy Panov inspired generations of students and researchers. His work will be remembered for pioneering new directions in science and advancing existing ones, as well as for his profound insights into animal and human behavior (Indeed, his latest four books are dedicated to human nature!).



A plate - excerpt, dedicated to the Red-backed Shrike behavior, from the monograph “*Die Würger der Paläarktis*” (1983, 1996).

Evgeniy Nikolaevich Panov died on 5 August 2024, just two days after his 88 birthday.

Acknowledgements

I am most grateful to Jevgeni Shergalin who helped by sending various sources of information about Prof. Panov’s life and work, as well as contacts of his students, now renowned scientists.

Boris Nikolov,
Head of the Bulgarian Ornithological Centre
Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences
1 Tsar Osvoboditel Blvd.
1000 Sofia
BULGARIA
E-mail: lanius.bg@gmail.com

Between late 1991 and 1993, I worked to persuade Evgeniy Panov to attend the 1st International Shrike Symposium at Archbold Biological Station in Florida. It was a challenging time for those in Eastern Europe and Soviet Russia due to the disintegration of the Iron Curtain. We secured funding to enable as many researchers as possible, including Evgeniy, to participate, provided they submitted a manuscript before the conference to demonstrate their commitment.

Evgeniy encountered difficulties understanding the Western scientific publishing process, including editing and peer review. It took extensive discussions to explain these concepts, which was a learning experience for both of us—me gaining insight into the Soviet perspective and Evgeniy learning about Western scientific practices.

His participation was a highlight of the symposium; he was warmly received and made close friends, especially with Tony Harris from South Africa. On the final day, as he prepared to leave, Evgeniy asked me to take soft drink cans from the conference for his daughters. He returned to Russia with a suitcase full of them.

Reuven Yosef
Ben Gurion University of the Negev, Eilat Campus

Photos: Evgeniy interacting with shrikeologists at the 1st International Shrike Conference, Archbold Biological station, Florida, U.S.A.

With Mrs Jan Woolfenden (back to picture) and Prof. Lucia Liu Severinghaus (Taiwan)

With Igor Gorban (Ukraine)

With Dr. Jack Tyler (U.S.A)

With Prof. Przemyslaw Busse and Barbara Diehl (Poland) back to camera, Dr. Reuven Yosef (Israel), Prof. Evgeniy Panov (Russia), Petras Kurlavicius (Lithuania)

With (L-R) Petras Kurlavicius (Lithuania), Prof. Uriel Safriel (Israel), Tony Harris (South Africa), Prof. Evgeniy Panov (Russia), Dr. John Fitzpatrick (U.S.A).

European Journal of Ecology, 2024, 10-13

A BRIEF LOOK ON THE TAXONOMY CHANGES IN SHRIKES SINCE 1960 WITH FOCUS ON THE *EXCUBITOR /MERIDIONALIS/BOREALIS* GROUP

Norbert Lefranc

Chemin du Bois Basselin, 88100 Saint-Dié des Vosges, France. norbert.lefranc@hotmail.fr

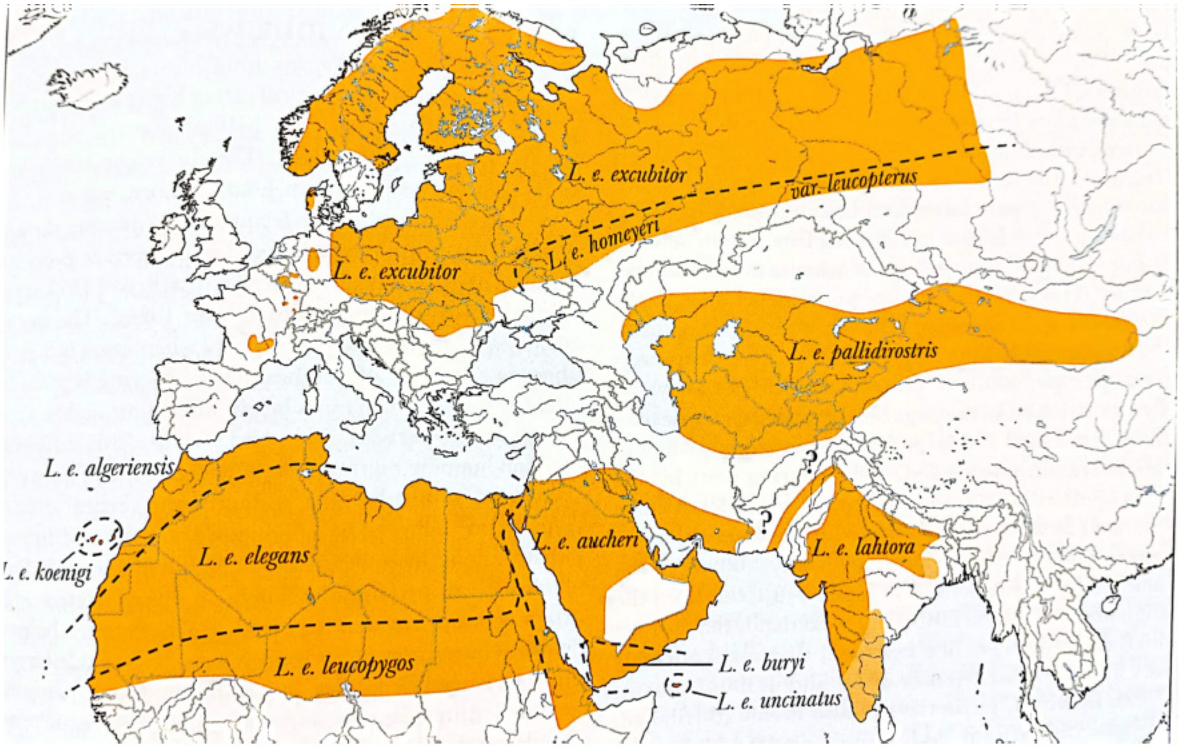


Figure 1. The different subspecies of *L. excubitor*. (map from Lefranc & Worfolk 2022)

Peters's Checklist of Birds of the World (1960) is a seminal work in bird taxonomy. Within the family Laniidae, as delineated by Austin L. Rand in volume 9, a total of 74 species are grouped across four subfamilies: Prionopinae, Malacotinae, Laniinae, and Pityriasinae, spanning 12 genera. Notably, the subfamily Laniinae encompasses two genera: *Corvinella,* comprising two species, and *Lanius,* housing 23 species. Additionally, *Eurocephalus* (white-crowned shrikes) are represented by two species. These are traditionally associated with the family Laniidae and find placement within the subfamily Prionopinae in this classification.

Over the years, numerous significant modifications have been proposed (*Cf.* history of the changes in Lefranc & Worfolk 2022).

The family Laniidae is currently regarded as monogeneric, with 32 species in the genus *Lanius.* The DNA analyses by Fuchs *et al.* (2019) indicate that the two species assigned to the genera *Urolestes* or *Corvinella* are part of the same clade as the *Lanius* species. Thus the Grey-backed Fiscal becomes *L. excubitoroides* and the Long-tailed Fiscal *L. cabanisi*. The same analyses confirm that the genus *Eurocephalus* is not closely related to the remaining species. McCullough *et al.* (2023) come to the same conclusion and propose to elevate the white-crowned shrikes to their own family: Eurocephalidae.

All these changes are mainly, but not exclusively, due to molecular approaches. Shortly, after even more genetic analyses, more shrike subspecies will likely be promoted to full species status. Based on just phenotypic characters, the so-called "Japanese" Brown Shrike *L. cristatus superciliosus* and the "Philippine" Brown Shrike *L. cristatus lucionensis* are already good candidates, as well as several subspecies of the Schach Shrike *L. schach.*

The changes in the last decades can be well illustrated by the example of the Great Grey Shrike *Lanius excubitor*, traditionally treated as a species with up to 19 subspecies (e.g., Rand 1960) and with a breeding range covering vast parts of Eurasia from Spain eastwards to the Indian subcontinent, but also the Middle East, North Africa, and the extreme north of North America (Fig. 1).

In the 1990s, following Vaurie (1959), it was sometimes divided into a northern and a southern subspecies group based on differences in morphology, ecology, and distribution (e.g., Cramp & Perrins 1993). In Lefranc & Worfolk (1997), the Great Grey Shrike was split into a northern (nine races) and a southern (11 races) species, thus following, among others, the suggestion of Panov (1995) in his paper on '*The superspecies of shrikes in the former USSR.'* Arguments in favor of this split concerned morphology, ecology, and geographical distribution (Cf. details in Lefranc & Worfolk 2022), including the fact that two taxa, *pallidirostris* (then attached to the southern subspecies group) and *mollis* (then northern subspecies group) co-existed geographically, and not infrequently syntopically, in an area of Mongolia.

This taxonomy was later contradicted by results from genetic studies, the most significant papers being Klassert *et al.* (2008) and Olsson *et al.* (2010). The latter paper deals with 18 taxa of the Great Grey Shrike complex. It shows a mitochondrial tree incompatible with the above-related division of the *L. excubitor* complex into a northern (*L. excubitor*) and a southern (*L. meridionalis*) species. Among the suggestions resulting from these findings: nominate Southern Grey Shrike *L. m. meridionalis* should be elevated to species status as it is genetically neither closely related to the nominate *excubitor* nor to the North African taxa regarded as its subspecies (*algeriensis, elegans, koenigi,* etc.).

Currently, three species are generally recognized: Great Grey Shrike *L. excubitor,* with 11or 12 subspecies; Iberian Grey Shrike (ex nominate 'Southern Grey'; Fig. 2) *L. meridionalis,* monotypic; and Northern Shrike *L. borealis,* with 3, 4, or 5 subspecies (e.g. Dickinson *et al*. 2014, Shirihai & Svensson 2018, Clements *et al.* 2019, Lefranc & Worfolk 2022, Gill *et al.* IOC checklist 2024).

The map (from Lefranc & Worfolk 2022; Fig. 1) shows the breeding distribution of the 11 *excubitor* races mentioned in the book. They are listed below with their English names following Shirihai & Svensson (2018) and sometimes with a few comments. The last two mentioned publications give more details, including descriptions.

- *L. e. excubitor* Great Grey Shrike.
- *L. e. homeyeri* Homeyer's Shrike

Identifying *homeyeri* remains a challenge for observers in the field, on photos, or in museums (skins) because of its strong resemblance to what is generally called the 'galliae' type in nominate. It is not always possible to assign a label!

Leucopterus is sometimes regarded as a pale morph of *homeyeri* (Dickinson *et al.* 2014, Shirihai & Svensson 2018). In Peter's Checklist (1960), *leucopterus* is listed as a valid race, a view still shared by Panov (2010). It is noteworthy that Tajkova & Red'kin (2014) synonymise *homeyeri* with *excubitor*, not an absurd option given the similarity with "galliae." For further details see that publication and discussion in Lefranc & Worfolk (2022).

Figure 2. Iberian Grey Shrike *L. meridionalis.* Bouches-du-Rhône, France, April (Camera trap, Olivier Hameau).

The precise breeding and wintering ranges of *homeyeri* and *leucopterus* (as well as their general biology) are still poorly known; the breeding ranges shown on the map are probably not quite correct and incomplete. .

- *L.e. algeriensis* 'Algerian Grey Shrike'
- *L.e. koenigi* 'Canary Islands Grey Shrike' (Fig. 3)
- *L.e. elegans* 'Elegant Grey Shrike'
- This taxon is sometimes referred to as 'Desert Grey Shrike'
- *L.e. leucopygos* 'Sahel Grey Shrike'
- *L.e. aucheri* 'Levant Grey Shrike'

Figure 3. 'Canary Island' Grey Shrike *L. excubitor koenigi.* La Graciosa, Canary Islands, November (Yves Muller).

Gill *et al.* (2024) also recognize *L.e.theresae* (northern Israël, southern Lebanon), here included in *aucheri*

- *L.e. buryi* 'Yemen Grey Shrike'
- *L.e. uncinatus* 'Socotra Grey Shrike'

This taxon, confined to an island off the Horn of Africa, was subsumed with *aucheri* by Kirwan (2007) as it is phenotypically very similar. DNA analyses, however, tell another story suggesting that *uncinatus* may even be a good candidate for species recognition (Olsson *et al.* 2010).

- *L.e. lahtora* 'Indian Grey Shrike'
- *L.e. pallidirostris* 'Desert Grey Shrike' (Fig. 4)

In the literature, this taxon was often, and sometimes still is, referred to as 'Steppe Grey Shrike,' but given its habitat characteristics, 'Desert Grey Shrike' appears much more adequate, a name already used by Dement'ev & Gladkov (1968) and later by Panov (2011).

Figure 4. 'Desert' Grey Shrike *L. excubitor pallidirostris.* Sohar, Oman, March (Annika Forsten).

Other 'more progressive" taxonomic treatments may also be found in the literature, as Olsson *et al.* 2010 state that the *Lanius excubitor* complex may be treated as at least six species. Thus within *Lanius excubitor* alone, the Dutch Committee for Avian Systematics (CSNA) recognizes four species: three polytypic: Great Grey *L. excubitor (excubitor, homeyeri,leucopteros)*, 'Asian' Grey *L. lahtora* (*lahtora, pallidirostris, aucheri, buryi*), 'Desert' Grey *L. elegans* (*elegans, leucopygos, algeriensis, koenigi*) and the monotypic Socotra Grey *L. uncinatus* (Poelstra 2010).

Two other recent examples: in his checklist of the *Birds of Moroccan Atlantic Sahara* (in French), Bergier *et al.* (2017) elevate the 'Desert' (here = Elegant) Grey Shrike to species status *L. elegans elegans* and also mention the presence of one of its subspecies: the 'Algerian Grey Shrike,' *L. elegans algeriensis.* In the *Atlas of Birds of Iran,* the 'Desert Grey Shrike' (named 'Steppe Grey Shrike') becomes a subspecies of the 'Indian Grey Shrike: *L. lahtora pallidirostris* (Kaboli *et al.,* 2016).

All these taxonomic proposals or modifications are interesting to follow, particularly with the progress in DNA analyses. But they may understandably create confusion in the birders' minds!

The good thing to remember is that when changes happen in one of our preferred World lists or our field guide, the affected taxa continue of course to exist and will not be less attractive.

In the case of the Great Grey Shrike, the Latin names indicated on the map will not change whether they refer to species or subspecies. In summer, in Uzbekistan, for instance, one is sure to be in *pallidirostris* country or in 'Desert Grey Shrike' country! While Latin names will not change, it is also hoped that there will be a certain stability in the use of English names as they appear in most scientific publications.

References

Bergier, P., Thévenot, M. & Qninba, A. 2017. *Oiseaux du Sahara Atlantique marocain.* Seof, Paris.

Clements, J.F., Schulenberg, T.S., Iliff M.J., Billerman, S.M., Fredericks, T. S., Sullivan B. L. & Wood C. L. 2019. The e-bird/ *Clements Checklist of Birds of the World* v. 2019.

Cramp, S. & Perrins, C.M. (eds). 1993. *The Birds of the Western Palearctic.* Vol 7. Oxford University Press, Oxford.

Dement'ev, G. P. & Gladkov, N.A. 1968. *Birds of the Soviet Union. Vol.6* Israël Program for Scientific Translation. Jerusalem.

Dickinson, E. C. & Christidis, L. 2014. *The Howard & Moore Complete Checklist of the birds of the World*. Vol. 2, 4th edn. Aves Press, Eastbourne.

Fuchs, J., Alström, P., Yosef, R. & Olsson, U. 2019. Miocene diversification of an open-habitat predatorial passerine radiation, the shrikes (Aves: Passeriformes: Laniidae). *Zool. Scripta* 48: 571-588.

Gill, F., Donsker, D. & Rasmussen (Eds). 2024 *IOC World Bird List* (v. 14.1).

Kaboli, M., Aliabadian, M., Tohidifar, M., Hashemi, A., Musavi, S.B. & Roselaar, C.C. *Atlas of Birds of Iran*. Department of Environment of Iran. University of Tehran.

Lefranc, N. & Worfolk, T. 1997. *Shrikes. A Guide to the Shrikes of the World.* Pica Press, Sussex.

Lefranc, N. & Worfolk, T. 2022. *Shrikes of the World.* Helm, London.

McCullough, J.M., Hruska, J.P., Oliveros, C.H., Moyle R.G. & Andersen, M.J. 2023. Ultraconserved elements support the elevation of a new avian family, Eurocephalidae the white-crowned shrikes. *Ornithology* 140: 1-11.

Olsson, U., Alström, P., Svensson, L., Aliabadian, M., Sundberg, P. 2010. The *Lanius excubitor* (Aves, Passeriformes) conumdrum-Taxonomic dilemma when molecular and non-molecular data tell different stories. *Mol. Phyl. & Evol.* 55: 347-357.

Panov, E. N. 1995. Superspecies of shrikes in the former USSR. In Shrikes (*Laniidae of the world: biology and conservation* (R. Yosef & F.E. Lohrer, eds). *Proc. West. Found. Vert. Zool*. 6: 26-33.

Panov, E. N. 2011. *The True Shrikes (Laniidae) of the World. Ecology, Behavior and Evolution*. Pensoft, Sofia & Moscow.

Poelstra, J. 2010. Trends in systematic. Speciation in shades of grey: the great grey shrike complex. *Dutch Birding* 32: 258-264.

Rand, A. L. 1960. Family Laniidae. In *Checklist of Birds of the World*. Vol 9 (E. Mayr & J.C. Greenway, Jr, eds).

Shirihai, H. & Svensson, L. 2018. *Handbook of Western Palearctic Birds*. Vol.2. Helm, London.

European Journal of Ecology, 2024, 14-19

CURRENT STATUS AND COMMENTS ON THE BIOLOGY OF THE IBERIAN GREY SHRIKE *LANIUS MERIDIONALIS* IN THE COUSSOUL (OR DRY CRAU) IN SOUTHERN FRANCE, BOUCHES-DU-RHÔNE

Norbert Lefranc[1*], Olivier Hameau[2] & Michel Lepley[3]

[1]*7 chemin du Bois Basselin, 88100 Saint-Dié des Vosges, France. norbert.lefranc@hotmail.fr*
[2]*LPO PACA Château de l'Environnement, 84 480 Buoux, France. olivier.hameau@lpo.fr*
[3]*864 rue des Houlles, 14310 Monts-en-Bessin, France. michel.lepley@gmail.com*
**Corresponding author*

Abstract.

This paper addresses the conservation status and biology of the Iberian Grey Shrike in a unique habitat: the Coussoul, a stony desert in southern France covering approximately 12,000 ha. It is well known among bird watchers as it is rich in wildlife and is home to the country's only Pin-tailed grouse population. Surveys from 1994, 2009 and 2023 showed that the shrike population exhibited a certain degree of stability in this relatively stable habitat, over the periods examined. In 2023, the total density was 0.75 occupied territories/100 ha. The main nest-sites are Rubus bushes, which punctuate the arid steppe. Some details are given about the species' diet which shows significant seasonal variations. The Coussoul Lanius meridionalis population represents between 5 and 10% of the total French population and we recommend that it be given more attention within the framework of the future management plan (2025-2034) of the existing National Nature Reserve created in 2001 and extending over 7,400 ha.

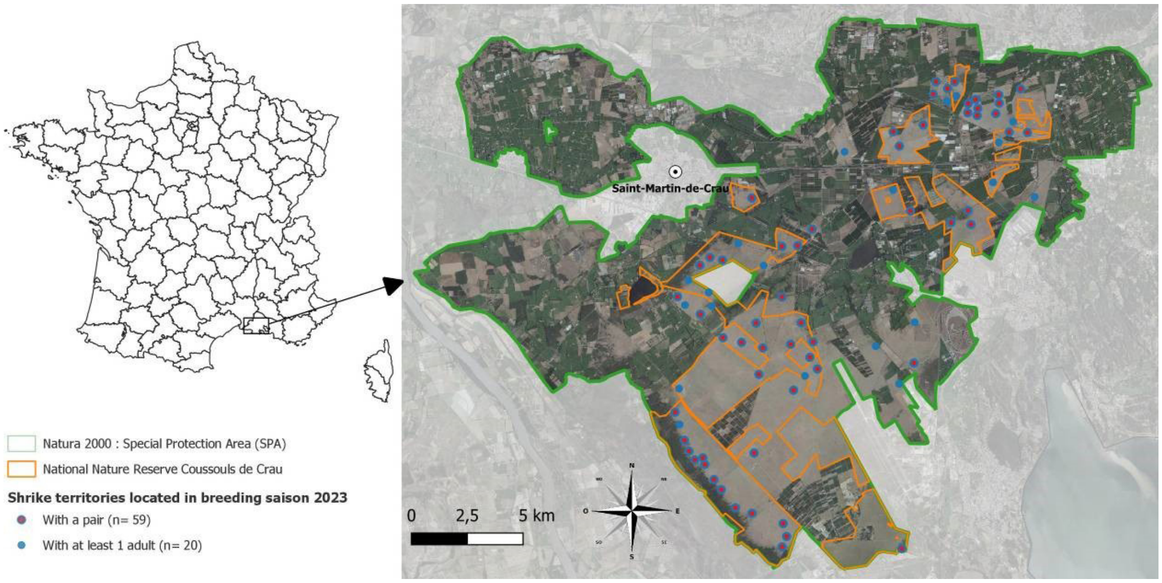


Figure 1. Map showing the location of the Crau in southern France.

Introduction

Lanius meridionalis, now generally recognized as a monotypic species, is a breeding bird restricted to the Iberian Peninsula and Mediterranean France. Its English name seems justified since about 95 % of the world's population lives in Spain and Portugal.

In France, the *Pie-grièche méridionale* is a regular breeder in 13 southern "départements" and its global population is estimated at 650 to 1150 pairs. In France it breeds in a wide range of landscapes, particularly in open *garrigue*, scrubland dominated by *Quercus coccifera*, including well-exposed and relatively rolling mountainous areas, generally below 1000m. It is also found in less natural, extensively cultivated areas, which often include vineyards, provided that there are some trees, but especially thorn bushes (*Prunus spinosa*, *Rubus* sp., *Rosa* sp.) and insect-rich dry pastures, fallow areas and abandoned fields (Lefranc & Worfolk 2022).

Here we provide information about the current status and biology of the species in a unique habitat in the Crau plain: the Coussoul, the only French desert, a stony desert. It has a Mediterranean climate and lies east of the Rhône Valley and the Camargue Delta. The main town with access to both the Camargue in the southwest and the Crau in the southeast is the historic city of Arles (Fig. 1).

MAIN CHARACTERISTICS OF THE CRAU PLAIN AND OF THE COUSSOUL

The Crau, a 600 km^2 plain in southeastern France, is roughly triangular in shape and lies between the cities of Arles (northwest), Lamanon (northeast) and Fos-sur-Mer (south). It is the ancient delta of the Durance River, and the stones that cover the very flat ground surface were transported by this river between approximately 650,000 and 35,000 years BC. The Coussoul or *Crau sèche* (dry Crau) is a semi-arid steppe consisting mainly of *Brachypodium retusum* and *Thymus vulgaris* in association with *Asphodelus fistulosus* and *Stipa capillata*. In Council Directive 92/43 EEC it is the priority habitat 6320: "Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea"*. It has been shaped by climatic conditions, the soil structure (the presence of conglomerate prevents the root growth of woody species over most of the steppe) and not forgetting sheep grazing that it has supported for 4000 years (Tatin *et al*. 2013 which see for more details).

The almost intact Coussoul covers slightly less than 12,000 ha (Fig. 2). Now fragmented into several patches, several different "coussouls" of different sizes and with different names, it is the remainder of the ca. 50,000 ha that existed in the 18th century before the area was progressively degraded, initially by agricultural activities that irrigated *Crau verte* (now known for the quality of its hay) and later, especially after the 1960s, by the Fos-sur-Mer industrial complex, the development of the motorway network, military areas, airports, quarries and industrial types of agriculture including shifting melon cultivation and large peach orchards (Cheylan 1998). Even though large parts of the plain are now part of the Natura 2000 network, which also includes a national nature reserve, serious threats remain.

Figure 2. The Coussoul. View of the northern limits with the Alpilles in the background. Good *meridionalis* habitats. *Olivier Hameau*.

The Coussoul is home to the only French population of the Pin-tailed Sandgrouse (*Pterocles alchata;* 400 to 800 individuals, CEN-PACA report 2016) and almost two-thirds of the national population of the Lesser Kestrel *Falco naumanni*. Other typical birds include the Little Bustard *Tetrax tetrax,* the Stone Curlew *Burhinus oedicnemus,* and the Calandra Lark *Melanocorypha calandra* (95 % of the national population; Tatin & Wolff 2015). Note that the characteristics of the Coussoul are well presented in an excellently illustrated book by Schall (2017).

CURRENT STATUS AND POPULATIONS TRENDS OF THE IBERIAN GREY SHRIKE

Historical data

The occurrence of the *Pie-grièche méridionale* in the Crau was mentioned as early as in the mid 19th century by Jaubert & Barthelemy (1859)*,* but the Crau vertebrate fauna only gained particular attention in 1965 with the publication of a first list by Otto von Frisch, who mentions some "*Lanius excubitor"* observations and a nest with seven nestlings ready to fledge in a dry bush on 27th May. Cheylan (1975), in his *Esquisse écologique de La Crau,* is the first to give some details about "*Pie-grièche grise"*: "its density is low in the (presumably central*)* coussouls (10 to 15 pairs), but higher in the periphereal areas (presumably in the western and northern parts) where potential nest sites are more numerous".

The recent surveys

Not a single *Lanius meridionalis* pair has ever been found nesting in the Crau plain outside the dry Crau, and so the surveys were limited to the 11,854 ha of the Coussoul, which consists of a central core of about 6,500 ha (Centre-Crau) and a series of satellite areas (particularly in the northern part of the plain) covering between 10 and 600 ha.

As part of a national survey of shrike populations launched by the *Ligue pour la Protection des Oiseaux* (LPO), a first survey of the Coussoul *meridionalis* population took place in 1994, carried out by the *Conservatoire et Etudes des Ecosystèmes de Provence* (C.E.E.P). It lasted five days in early May with the participation of 25 people (Lefranc & Lepley 1995). This was followed by another in 2009: 11 (mostly windy, rainy) days in May and six people (Lefranc & Vincent-Martin*, unpubl*.) and a more sophisticated one in 2023, when the Coussoul was divided into 26 survey areas with an average 456 ± 227 ha, and with the participation of 27 people: first passage at each site between 3rd March and 12th April (date chosen by the observer) and second passage between 19th and 27th April (mainly in the form of a prospecting camp (Hameau 2023).

In all cases, the main field work began at dawn and lasted approximately 5 hours. Access to State land (including military areas), local authority land, private property, etc., as well as the use of cars on normally closed roads or tracks had been ensured well in advance by the organizers. Observers were advised to stop periodically and scan the landscape for at least 15 minutes. Each shrike observation was detailed on a 1/25000 map and assigned a number; behavioral observations (song, capture or carrying prey, nest location, etc.) were recorded in a special file.

The following results emerged with regard to the number or specific breeding pairs and territories:

1994 : 46-66 ; **2009** ; 35-45 ; **2023** : 59-79.

The 2009 survey provides minimal results as it was conducted primarily by only one person with only one passage per site and in sometimes unfavorable weather conditions. By extrapolation the number of occupied territories that year was estimated between 56 and 66.

The years 1994 and 2023 are more comparable and it seems reasonable to assume that the population of dry Crau *Lanius meridionalis* shows at least some stability over the time considered.

Habitat, densities and nesting sites.

In the flat stony landscape of Coussoul (between 1 and 9 meters a.s.l.), only a few vertical features catch the eye: especially the one-story sheepfolds (there are 24 *bergeries* within the boundaries of the nature reserve alone), a few old wells and of course the ca. 40,000 sheep present from February or March to mid to late June (Fig. 3). Another very striking feature: thousands of cairns, remnants of World War II, built by prisoners in July 1944, when the German command decided to prevent Allied aircraft from landing on the seemingly ideal terrain that the dry Crau offered.

Figure 3. Sheep grazing in the Coussoul. Photo by Norbert Lefranc

The cairns, sometimes mixed with soil, are not very high but provide important perches for the shrikes, which often fly very low before sweeping up to a new vantage point, often a stone. Bramble *Rubus* sp. and *Phyllirea angustifolia* bushes, important nesting sites, develop well among the stones, especially between the cairns (Fig. 4). They punctuate almost the entire Coussoul and are rare, small or absent only in their central part. In peripherial areas in the north and southwest, Holm oak *Quercus ilex* offer important nesting sites.

Figure 4. Typical nesting site (*Rubus* bush) in the foreground. Cairns and bushes in the steppe: good habitat for *meridionalis*. Note a distant *Bergerie*. *Norbert Lefranc.*

The density of breeding pairs obviously depends on the availability of suitable nesting sites. In 2023, the total density was 0.75 occupied territories/100 ha. Locally it reached 1.73/100 ha or was only 0.35/100 ha as in the case of "Centre Crau" (Hameau 2023). Lepley *et al.* (2000) studied a breeding population for two years, 12 pairs each time, in a ca. 1,000 ha area. The density was ca. 1 pair100 ha and the distances between nests (first clutches) varied somewhat between years: mean of 938m (750-1225) in the first year and a mean of 710m (250-1125) the second year.

Of 67 nests, 42 (62%) were in bramble *Rubus* sp, 7 (10%) in *Phillyrea angustifolia,* and 18 (26%) in Holm oak *Quercus ilex.* (Lepley *et al.* 2000; Lefranc, *unpubl.*). In *Rubus* bushes, nests are generally about 1m above the ground (0.4-1.1 m; Fig. 5). In the "Centre Crau", where shrike density is low, bushes are relatively numerous but small, nests are sometimes clearly visible and appear vulnerable. In other areas, nests are concealed in large bushes, and are potentially less accessible to predators.

Figure 5. A shrike near its nest in a *Rubus* bush. *Olivier Hameau.*

The shrike's habitat in this stony desert is stable, but important changes can also occur locally within a short period of time. Comparisons between the 1994 and 2009 surveys showed that a relatively large area in the north-east (coussoul du Grand-Brahis and La Tapie) had become largely unsuitable as a foraging habitat. This was apparently due, at least in part, to the lack of grazing, which led to the development of tall vegetation, in the form of an "ocean" of bramble bushes. The shrike population fell from nine occupied territories to just two (Lefranc & Vincent Martin *unpubl*.)

Population size and density in the Crau sèche are not known for the winter. A study conducted in Spain that sexed ringed birds using molecular genetic techniques showed that most adult males were largely resident, with high fidelity to specific territories, while females, were much more prone to movement (Campos & Martin 2010).

The relatively few birds that are in the neighboring Camargue outside of the breeding season (early August to early March, e.g. Kayser *et al.* 2014) probably come from the Coussoul and are presumably predominantly female; much of the data relates to the well-known Tour du Valat area, where up to around four pairs nested until ca. 2000 in a specific, small and rare habitat, now perhaps too dense and unsuitable *Phyllirea* shrubs growing in the sandy soil (NL pers.obs.). Movements to and from the Alpilles, a limestone mountain range to the north that hosts a small breeding population of *Pie-grièche méridionale*, also seem likely.

Notes on breeding biology

In Coussoul, egg laying begins in the last week of March and the first eggs for repeat clutches can be recorded in June. Lepley *et al*. (2000) found that most eggs (80 %) were laid between 10th April and 10th May. The clutch varied between three and seven eggs (mean 5.2 ± 1.1 for n = 22; Fig. 6). Over the course of two years, the 24 pairs monitored laid 137 eggs; hatching success was 54% , fledging success was 27% and overall breeding success was 1.54 (± 1.93) fledged young per breeding pair. More than half of the pairs (54, 17%) that built at least one nest did not produce a single fledgling. The predation rate on eggs and nestlings was high: 44 % of the nests were predated (probably by Magpies *Pica pica*); approximately 16% of nests that were either empty or containing clutches were abandoned, but this never occurred in nests with nestlings. No second brood was recorded, but 50% of pairs that lost their eggs or young in the nest made a second attempt. In only one case was there a third attempt.

Foraging and food

Meridionalis hunts in the typical shrike sit-and-wait manner, with most prey captured on the ground. In the Coussoul, where trees are rare except along canals and in marginal areas, the average perch-height is about 2 m (1-3 m; Fig. 7). Hovering for a few seconds, a few meters above the ground may occur, particularly when perches are rare.

Figure 6. A 7-egg clutch in a *Phillyrea* bush. *Norbert Lefranc.*

Figure 7. On the hunt from the top of a pile of stones. *Norbert Lefranc.*

Some insight into the local diet of *meridionalis* was gained through direct observations, prey found in larders (Cheylan 1975) and through identification of prey from regurgitated pellets (Lepley 1995; Vivat 1998; Lepley *et al.* 2004*)*.

In the Coussoul, impaled prey are rarely recorded, but caches are necessary when vertebrates, mainly small passerines, are captured, which occurs rarely. Remains of the following species were found in larders: Mammalia: Pygmy white-toothed Shrew *Suncus etruscus*, Greater white-toothed Shrew *Crocidura russula*, Wood Mouse *Apodemus sylvaticus*; Aves : Stonechat *Saxicola torquatus*, Skylark *Alauda arvensis*, Tawny Pipit *Anthus campestris*; Reptilia: unidentified small lizards presumably Common wall lizard *Lacerta muralis*; Amphibia: Edible frog *Rana esculenta,* Mediterranean tree frog *Hyla meridionalis.* Among the impaled arthropods: the Megarian banded centipede *Scolopendra cingulata*, and one of the largest spiders of France, Tarantula wolf spider *Lycosa tarantula*.

The Coussoul hosts a rich, diverse arthropod community well adapted to this particular habitat, which includes the endemic Crau Plain grasshopper *Prionotropis rhodanica* (Massa *et al.* 2015) and the near-endemic beetle *Acmaeoderella cyanipennis perroti*. Grazing intensity, which varies from site to site, certainly has a direct influence on the diversity and abundance of insects; for example, many grasshoppers require a specific vegetation structure (Bröder *et al.* 2023).

A total of 5,409 prey were identified from 257 pellets collected during a single breeding and winter period showed that vertebrates were rarely captured and that the major groups were: Coleoptera (26, 64%), Orthoptera (12, 93%), Hymenoptera (4, 72%) and Arachnida (10, 65%). High seasonal preferences were found. Coleoptera were recorded in large quantities throughout the year; Carabidae were the main prey in winter, Melolonthidae were particularly important for the adults during the nestling period (*Amphimallon ruficorne* accounted for 29% of the wet biomass) and Cetoniidae (particularly *Netocia oblonga* and *N. morio*) for the fledglings. Hymenoptera were largely consumed in autumn and Arachnida in autumn and winter. Orthopterans dominated the diet in summer and autumn, with large numbers available as early as June (essential for juveniles), with approximately 50,000 individuals/ha in August, before a gradual decline until November (Foucart, 1997). Lepidoptera larvae were eaten by fledglings in winter and spring.

Conservation and perspectives

The Crau sèche *meridionalis* population accounts for between 5 and 10% of the total French population. A Special Protection Area (SPA, Birds Directive) covers 39,333 ha of the Crau plain and includes the *Réserve Naturelle Nationale des Cousssouls de Crau,* created in 2001, with an area of 7,400 ha, including 6,343 ha of Coussouls. Notably, almost 60% of the territories occupied in 2023 lie within the boundaries of this reserve. It is hoped that this percentage will increase in the near future as steps are currently being taken to add ca. 3,152 ha of Coussouls for the reserve.

The current management plan of the reserve (2015-2024; Wolf *et al*. 2015) logically devotes a lot of space to the *Principales espèces d'oiseaux* (listed above; Fig. 8), but unfortunately only devotes two lines to the *Pie-grièche méridionale*. The species has been in sharp decline in its breeding range worldwide and it has been listed as *Vulnerable* on the IUCN Red List since 2017 (Lefranc & Worfolk 2022). Given the regional and national importance of the Crau sèche *meridionalis* population, the value of this shrike to local cultural heritage certainly merits reassessment in the forthcoming updated management plan (2025-2034). Of course, particular attention should be paid to maintaining adequate habitat and research into various aspects of species' biology should be encouraged; a ringing program that began 20 years ago but was abandoned (Andrew Newton *viva voce*) could be restarted to gain a better understanding of the respective movements of adults, first-winters, males and females, as well as survival, predation risk, etc. A specific survey carried out regularly over a yet to be determined period (between 5 and 10 years?), seems desirable.

Figure 8. The emblematic Coussoul species : Pin-tailed Sandgrouse (400 to 800 individuals in this arid desert). *Yann Toutain*.

Access to the Coussoul

A bird trip to the south of France invariably includes the Camargue, the Crau sèche and the Alpilles, generally in that order. Most roads crossing the Coussoul are normally closed, so access is largely prohibited. However, there is one excellent place: the Peau de Meau area (129 ha) in the National Nature Reserve. Peau de Meau is a *Bergerie* with an inbuilt observatory. A 4-km long path leads there from the car park. On your way there is a good chance of seeing most bird species, especially early in the morning, including the Pin-tailed Sandgrouse and the Iberian Grey Shrike. If you are lucky, you might even catch a glimpse of the elusive and impressive Ocellated Lizard *Timon Lepidus,* another flagship species of Crau sèche, believed to host one of the largest populations in France (Tatin *et al* . 2016). Access to this part of the reserve is possible, although a permit must be obtained for 2 days (not necessarily consecutive) and for a few Euros at the Maison de la Crau (Ecomusée), 2 Place Léon Michaud in Saint-Martin-de-Crau where further information can be provided. The nature reserve is jointly managed by *the Conservatoire d'Espaces Naturels de Provence-Alpes-Côte d'Azur (CEN PACA)* and the *Chambre d'Agriculture des Bouches-du-Rhône (CA 13).*

Acknowledgments

Our warmest thanks go to many people for their help in conducting and coordinating the shrike surveys and/or for their field participation : the staff of *the Réserve Nationale des Coussouls de Crau*, members of the *Ligue pour la Protection des Oiseaux* and/or the *Conservatoire* *d'Espaces Naturels de Provence-Alpes-Côte d'Azur* not forgetting the shrikeologists from Luxembourg and Belgium (detailed lists in the reports already published).

References

Bröder, L., Tatin, L. & Hochkirch, A. 2023. Quantifying predation to insects: An experimental approach. *Global Ecology and Conservation* 44: e02485/

Campos, F. & Martin, R. 2010. Spatial and temporal distribution of Southern Grey Shrikes *Lanius meridionalis* in agricultural areas. *Bird Study* 57: 84-88.

CEN-PACA report 2016. Compte-rendu du dénombrement des Outardes et Gangas hivernants en Crau et en PACA-24 janvier 2016. Conservatoire d'espaces naturels Provence-Alpes-Côte d'Azur. 4 pages.

Cheylan, G. 1975. Esquisse écologique d'une zone semi-aride : La Crau (Bouches du Rhône). *Alauda* 43 : 23-54.

Cheylan, G. 1998. Evolution du milieu naturel et du peuplement ornithologique de la Crau. In *Patrimoine Naturel et Pratiques Pastorales en Crau*. Conservatoire Etudes et Ecosystèmes de Provence (CEEP) & Chambre d'Agriculture des Bouches du Rhône, eds.

Foucart, A. 1997. Inventaire et dynamique annuelle du peuplement acridien de la plaine de la Crau sèche (Bouches-du-Rhône, France) (Orthoptera, Acridoidea*). Bull. Soc. Entomologique. de France* 102 : 77-87.

Frisch, (O. von). 1965. Beiträge zur Kenntnis der Wilbeltiere der Crau, Südfrankreich. Biologie und Oekologie. *Bonner Zoologische Beiträge* 16 : 92-126.

Hameau, O. 2023. Recensement de la Pie-grièche méridionale *Lanius meridionalis* dans les coussouls de Crau. *Faune-Paca Publication* 119.

Hochkirch, A., Tatin, L. & Stanley Price M. 2014. *Crau plain grasshopper. A strategy for its Conservation 2015-2020*. IUCN-SSC& CEN PACA, Saint-Martin de Crau.

Jaubert, J.B. & Barthelemy-Lapommeraye, C. J. 1859*. Richesses Ornithologiques. Midi de la France*. Barlatier-Feissat et Demonchy, Marseille.

Kayser, Y., Blanchon, T., Galewski, T., Gauthier-Clerc, M., Poulin, B., Thibault, M., Massez, R., Tiné, N., Sadoul, N., Pin, C., Chérain,Y., Vandewalle, P., Vialet, E., Paulus, G., Vincent-Martin, N., Ponchon, C., Pilard, P., Flitti, A., Isenmann, P. & Béchet, A. 2014. *Compte-rendu ornithologique Camargue-Crau-Alpilles pour les années 2007-2012.* Tour du Valat & SNPN/ Réserve nationale de Camargue.

Lefranc, N. & Worfolk, T. 2022. *Shrikes of the World*. Helm, Bloomsbury, London.

Lefranc, N. & Lepley, M. 1995. Recensement de la Pie-grièche méridionale en Crau sèche. *Faune de Provence (CEEP)* 16 : 87-88.

Lefranc, N. & Vincent-Martin, N. Recensement de la Pie-grièche méridionale en Crau sèche en 2009. *Unpublished notes and distribution map.*

Lepley, M. 1998. *Alimentation et reproduction de la Pie-grièche méridionale Lanius meridionalis meridionalis (Temminck, 1820) en Crau sèche (Bouches-du-Rhône-France).* Mémoire EPHE, Montpellier.

Lepley, M., Guillaume; Cl-P., Newton, A. & Thévenot, M. 2000. Biologie de reproduction de la Pie-grièche méridionale *Lanius meridionalis* en Crau sèche (Bouches-du-Rhône-France). *Alauda* 68 : 35-43.

Lepley, M., Thévenot, M., Guillaume, Cl-P., Ponel, P. & Bayle, P. 2004. Diet of the nominate Southern Grey Shrike *Lanius meridionalis meridionalis* in the north of its range (Mediterranean France). *Bird Study* 51: 156-162.

Massa, B., Ünal, M., & Lo Verde, G. 2015. Revision of the genus *Prionotropis* Fieber, 1853 (Orthoptera : Pamphagidae : Thrinchinae). *Zootaxa* 4059: 499-524.

Schall, A. 2017. *La Crau, dernière steppe pierreuse.* Biotope éditions, Mèze.

Tatin, L. & Wolff, A. 2015. Alouette calandre *Melanocorypha calandra* in Issa, N. & Muller, Y. 2015. *Atlas des oiseaux de France métropolitaine. Nidification et présence hivernale.* LPO/SEOF/MNHN. Delachaux et Niestlé, Paris.

Tatin, L., Renet, J.,Wolff, A., Marchand M-A., & Besnard, A. 2016. Que connaissons-nous de l'état de conservation de la population de lézards ocellés *Timon lepidus* (Daudin, 1802) (Sauria: Lacertidae) de Crau ? *Bull. Soc. Herp. Fr.* 160 :15-24.

Tatin, L., Wolff, A., Boutin, J., Colliot, E. & Dutoit, T. 2013. *Ecologie et conservation d'une steppe méditerranéenne. La plaine de Crau*. Quae, Versailles.

Vivat, A. 1998. Alimentation et utilisation de l'habitat de deux oiseaux insectivores : la Pie-grièche méridionale et le Faucon crécerellette. In *Patrimoine Naturel et Pratiques Pastorales en Crau*. Conservatoire Etudes et Ecosystèmes de Provence (CEEP) & Chambre d'Agriculture des Bouches du Rhône, eds.

Wolf, A., Tatin, L. & Sauguet F. 2015. *La Réserve Naturelle des Coussouls de Crau. Plan de gestion 2015-2024.* CEN PACA & Chambre d'Agriculture Bouches-du-Rhône.

European Journal of Ecology, 2024, 20-22

LESSER GREY SHRIKE *LANIUS MINOR* AT THE NORTH-WESTERN EDGE OF ITS RANGE: COMMENTS TO POPULATION DECLINE AND MIGRATION STRATEGIES

Anton Krištín

Institute of Forest Ecology SAS, Ľ. Štúra 2, SK-96053, Zvolen, Slovakia (email: kristin@ife.sk)

Abstract.

Many long-distance migratory birds are endangered on different geographical scales, continental, regional, and local. The Lesser Grey Shrike belongs to such species and shows a strongly negative population and area trend, especially in the west of the range. During three decades, we monitored the breeding pairs density of the species in the northwest of the area (20 km^2, Slovakia) and the effects of the modernization of traditional farming area on its population trend. Furthermore, we used geolocators to study its migration behavior, migration routes, stopovers, and wintering grounds, with the aim of knowing the areas where the species may be endangered during migration. We found that the modernization of the rural landscape and the abandonment of the farming lifestyle are strongly correlated with the species' population decline. Also, by observational data of birdwatchers, we partly confirmed that the species moves to South Africa by anti-clockwise loop flight. We found that the site-to-site distance is 8200 km in autumn and 9500 km in spring, with much faster spring migration than autumn (45 vs. 114 days). We localized four stopovers (total mean 97 d) during the autumn migration and three during the spring (total mean 13 d). The wintering grounds were in Botswana, and the birds spent 136-144 days there. Therefore, attention should be paid to protecting the species' environment at breeding sites, known stopovers, and wintering grounds.

Keywords: *shrikes, population trends, long-distance migration, ecology*

Introduction

Birds of agricultural systems are one of the most threatened groups of birds in the world mainly due to their sharp population decline in recent decades (Giralt et al. 2008, Stanton et al. 2018). Many shrikes as strictly insectivorous birds are declining, and some frequently inhabit the farmland habitats. The Lesser Grey Shrike is a typical Palaearctic songbird, declining strongly in the north-western range since the middle of 20 century (Lefranc and Worfolk 1997, Lefranc 2023). We studied several aspects of its ecology and behavior at the north-western range edge in the traditional farming area of Slovakia (e.g., Krištín 1995, Krištín et al., 2000, 2007, Hoi et al., 2012). Recently, we summarized the long-term information on the modernization of the rural environment as one of the factors of local population decline in the species (Krištín et al., 2024). As the species is a long-distance migrant to South Africa and is also endangered along the European-African pathway and in winter quarters, we brought new light on species migration strategies using two types of loggers (Adamík et al., 2023, 2024).

Population Decline

In the last century, modernization and intensification of agriculture have been primarily responsible for the dramatic decline in farmland biodiversity. Also, rural settlements have been subject to radical changes due to modernization, but their impact on bird populations could have been better quantified. The Lesser Grey Shrike is a threatened flagship farmland bird already extinct in many western and central European countries. We monitored a population of this long-distance migrant in a traditional farming area in the Poľana Mountains (Slovakia, 20 km^2) in three breeding seasons (1996, 2016, 2021). In the study area, 106 territories/nests of the species were recorded, of which 78% were occupied in one, 18% in two, and only 3% in all three study years. The number of breeding territories decreased from 73 in 1996 to 38 in 2016 and 22 in 2021. As the population has declined, the breeding area has also shrunk significantly. For this study, we, therefore, categorized homesteads according to their occupancy type, management, and renovation, which also reflects differences in surrounding habitats, e.g., vegetation structure and complexity, presence of trees and shrubs (Hiron et al., 2013; Rosin et al., 2016). We investigated whether and how the modernization of settlements over almost three decades affects one of the most important breeding populations of the Lesser Grey Shrike in Central Europe (Krištín et al., 2000; Hoi et al., 2012; Lefranc and 2023). We analysed the impact of the increase in modern habitations and the decrease in traditional farmsteads on the population decline. While there were no modern houses in the breeding territories in 1996, their number has increased to the number of farmhouses by 2021. Building a single modern house in a territory reduced the probability of nesting to about 6%. This effect was also evident when one or two farms were still present (17% and 40% respectively). A further modern house in the territory reduced the nesting probability to almost zero, even if a farm was present (Krištín et al. 2024). In this long-term empirical study, we identified these changes as a local threat factor for the species studied. The presented results may help design and implement conservation measures in traditional farming landscapes, not just in Europe.

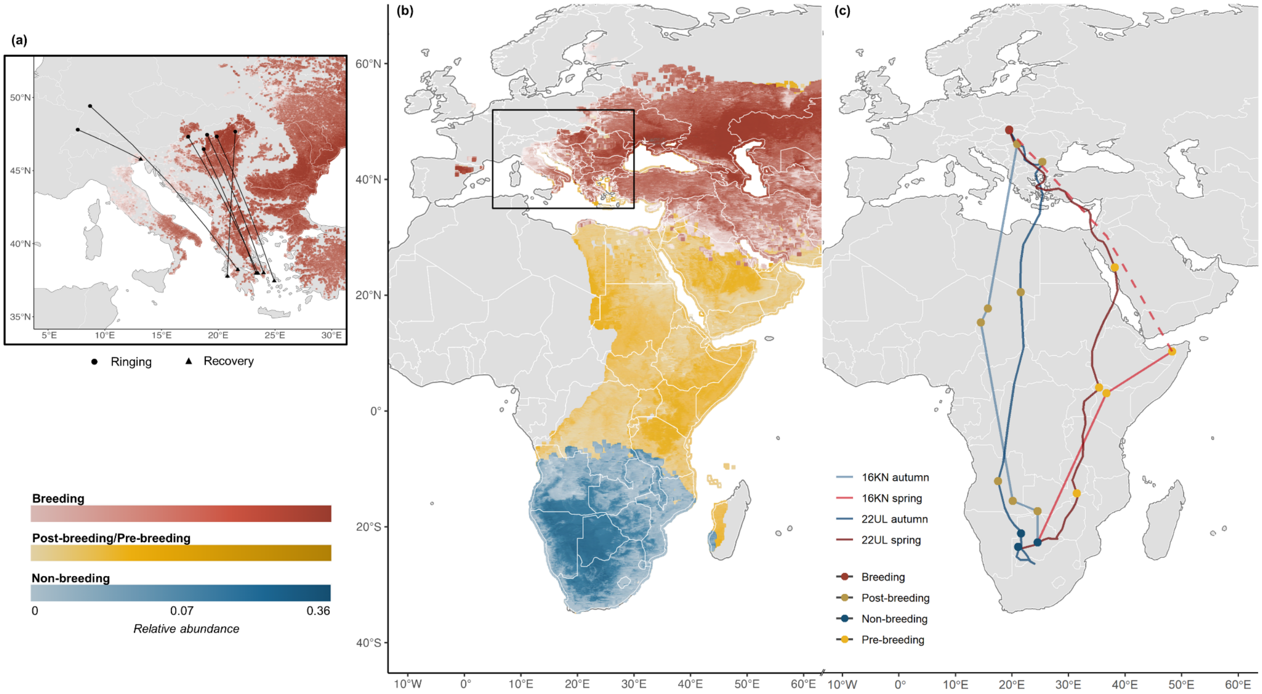


Fig. 1. Lesser Grey Shrike estimated migration tracks and stationary sites/stopovers used by two individuals: 16KN (autumn = light blue, spring = light red) and 22UL (autumn = dark blue, spring = dark red) in this study. The track of 16KN was estimated using *GeoPressureR*, and shows the shortest most likely path of the bird. The great circle distance between the two sites is the dashed portion of the track connecting the last pre-breeding stopover site to the breeding site. The track of 22UL was estimated using *SGAT* and shows the median most likely path of the bird. The circles indicate the stationary sites used during each season (red = breeding, dark yellow = post-breeding, blue = non-breeding, light yellow = pre-breeding). Stationary sites were defined as stops ≥48h (Adamík et al. 2024).

Migration Strategies

We also need to gain more knowledge of the species migration ecology. All that was known about its non-breeding movements is inferred from observational data of birds on the passage (Dowsett 1971, Lefranc & Worfolk 1997, Lefranc 2023). We deployed two types of loggers, light-level geolocators and multi-sensor loggers, on 20 birds from a declining Slovak breeding population; we present the first direct evidence for non-breeding grounds, loop migration, stopover sites and the timing of annual cycle events (Adamík et al. 2024). In 2017, we equipped ten birds (eight males and two females) with GDL3-PAM multi-sensor loggers (Swiss Ornithological Institute, Sempach). In 2019, we equipped another ten birds (six males and four females) with uTags (Swiss Ornithological Institute, Sempach). In the following years, we detected four birds (males only) with loggers. We retrieved three loggers and one bird we failed to catch. Return rates of logger-tracked birds were 28.6% (4/14) for males and 0% (0/6) for females. With barometric data, we recorded details on flight altitudes during migration. The two tracked males with complete migration cycles migrated to Southern Africa in an anti-clockwise loop (Fig. 1).

Autumn migration tracks went through the Balkan Peninsula and the Mediterranean Sea towards Libya, with unusually long stays around N Chad and Niger. The next stopovers were in Angola, and the main non-breeding/wintering sites were in Botswana. Spring migration commenced on March 29 and April 7, and the birds took routes along East African countries, with stopovers later in Somalia and Saudi Arabia, before crossing the eastern Mediterranean Sea. Nocturnal migration dominated, but for three days in August, while crossing the Sahara Desert, the bird extended flights into the day with a sudden increase in flight altitudes at dawn. Flight altitudes were higher during barrier crossing and the last phase of spring migration compared to the remaining periods, with the most extreme event recorded at 4530 m asl.

Conclusions

1. Traditional human dwellings in rural areas provide essential breeding habitats for declining farmland birds. Detailed knowledge of the impact of their modernization on biodiversity is crucial for the effective conservation of species. In line with the Lesser Grey Shrike's breeding habitat requirements, this is mainly associated with the absence of animal husbandry and horticulture, the loss of tall fruit trees, and, on the other hand, the creation of 'sterile' lawns and the planting of low ornamental trees that are not suitable for nesting. Our study has shown that farmsteads offer an opportunity to promote hands-on nature conservation awareness to farmers, who are important stakeholders in agroecosystems.

2. The migration routes were precise and quantified. Key stopover sites were found in Romania, Bulgaria, N Chad, and N Niger & Angola in autumn, and Mozam-

bique, Kenya, Somalia & Saudi Arabia in spring. Critical wintering grounds are in Botswana. The birds migrate mainly in the night and flight altitude shows significant annual changes. Spring migration is much faster than autumnal. The species needs massive conservation actions at breeding sites, known stopovers, and wintering grounds.

Acknowledgments

I thank all the co-authors of our cited studies and P. Tuček for their help in the field. Funding was partially provided by VEGA grants Nos. 2/0065/20 and 2/0018/24 and Czech Science Foundation 20-00648S grants.

References

Adamík P, Wong JB, Hahn S, Krištín A (2023) Data from: Non-breeding sites, loop migration and activity patterns over the annual cycle in the Lesser Grey Shrike *Lanius minor* from a north-western edge of its range (1.0) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.7556866

Adamík P, Wong JB, Hahn S, & Krištín A (2024). Non-breeding sites, loop migration and flight activity patterns over the annual cycle in the Lesser Grey Shrike *Lanius minor* from a north-western edge of its range. *Journal of Ornithology* 165(1), 247–256.

Dowsett RJ (1971) The Lesser Grey Shrike in Africa. *Ostrich* 42, 259–269

Giralt D, Brotons L, Valera F, & Krištín A (2008) The role of natural habitats in agricultural systems for bird conservation: the case of the threatened Lesser Grey Shrike. *Biodiversity and Conservation* 17, 1997–2012.

Hiron M, Berg A, Eggers S, Pärt T (2013) Are farmsteads overlooked biodiversity hotspots in intensive agricultural ecosystems? *Biol. Conserv.* 159, 332–342. https://doi.org/10.1016/j.biocon.2012.11.018

Hoi H, Krištín A, Valera F & Hoi C (2012). Traditional versus non-traditional nest-site choice: alternative decision strategies for nest-site selection. *Oecologia* 169, 117–124.

Krištín A (1995) Why the lesser grey shrike (*Lanius minor*) survives in Slovakia: food and habitat preferences, breeding biology. *Folia Zool.* 44, 325–334.

Krištín A, Hoi H, Valera F, Hoi C (2000) Breeding biology and breeding success of the Lesser Grey Shrike (*Lanius minor*) in a stable and dense population. *Ibis* 142, 305–311. https://doi.org/10.1111/j.1474-919X.2000.tb04870.x

Krištín A, Hoi H, Valera F, Hoi C (2007) Philopatry, dispersal patterns and nest-site reuse in Lesser Grey Shrikes (*Lanius minor*). *Biodivers Conserv* 16, 987–995. https://doi.org/10.1007/s10531-006-9019-8

Krištín A, Hoi H & Kaňuch P (2024). Local population decline of the threatened Lesser Grey Shrike *Lanius minor* is linked to the modernisation of the rural landscape. *Bird Conservation International 34*, e18.

Lefranc N, Worfolk T (1997) Shrikes. A Guide to the Shrikes of the World. Pica Press, Sussex

Lefranc N (2023) Shrikes of the world. Helm Identification Guide Series.

Rosin ZM, Skórka P, Pärt T, Żmihorski M, Ekner-Grzyb A, Kwieciński Z, Tryjanowski P (2016) Villages and their old farmsteads are hot spots of bird diversity in agricultural landscapes. *J. Appl. Ecol.* 53, 1363–1372. https://doi.org/10.1111/1365-2664.12715

Stanton RL, Morrissey CA, & Clark RG (2018) Analysis of trends and agricultural drivers of farmland bird declines in North America: A review. *Agriculture, Ecosystems & Environment* 254, 244–254.

European Journal of Ecology, 2024, 23-24

FIELD EVIDENCE SUGGESTS THAT SOME MIGRANT LOGGERHEAD SHRIKES BREED ON WINTERING GROUNDS

Susan H. Craig

Colorado Springs, Colorado, United States of America

Abstract.

I describe evidence gathered over 25 years of in-hand examination for banding free-flying loggerhead shrikes (Lanius ludovicianus) in the field. Nestlings were not studied nor banded. Close examination of plumage, molt, wing and tail measures gives more precise information than any other means. Although I sometimes encountered young birds of questionable age during spring migration in Colorado, this winter-breeding hypothesis did not emerge until finding nestling shrikes in Texas in January and February. Then, combined with the capture of young shrikes in late February and April in Colorado, this hypothesis was created.

Key words: *Winter-breeding, wintering territory, migrant loggerhead shrike, very young birds (<40d), treadle-door trap, banders, stable isotope analysis*

Introduction

I first became intrigued by loggerhead shrikes when I accidentally caught one on a Bal-chatri trap I'd thrown for a hawk in Florida in the late 1980s. The hawk moved on, but the mouse in the Bal-chatri attracted a shrike, which was caught in one of the trap's nooses. Freeing this feisty little bird left me bloodied, but the encounter ignited my curiosity. Shrikes are not popular birds, since they're listed as "predatory songbirds". For the most part, they catch insects, but also lizards, small snakes, roadkill, mice, and an occasional bird. Prey is often impaled on thorns, barbed wire or yucca tips, which may allow toxins in prey such as anole lizards or lubber grasshoppers to degrade. A row of impaled prey is often used by male shrikes to attract females. This behavior has earned shrikes the nickname "butcher bird".

Capture Methods

After a lot of thought and experimentation with different designs, I finally created a circular treadle-door trap that worked very well; my capture rate was 96%. During the past 25 years, I've spent many hours touring back roads in eastern Colorado and nearby states. Central flyway shrikes breed on Colorado's eastern plains, but winter farther south in New Mexico, Texas and Mexico. My trap was baited with a small mouse, safely housed in a protective cage in the center of the trap. When a perched shrike was spotted, I lowered the trap through the car window to the side of the road, backed up the car, then waited for the shrike to approach.

"Loggerhead" means large head (full of muscles), and shrikes are notorious biters. It's been shown that the bite of a shrike is, gram for gram, stronger than any raptor (Diego Sustaita, pers. comm.). The shrike's sharply hooked bill prompted me to invent a handling method using a short, closed-end tube. I drilled air holes in the bottom of a clean plastic spice bottle measuring 1&3/4" in diameter, then cut off the top end so the tube measured about 4" long. Tubes are made from spice bottles containing only parsley or thyme, never from chili, pepper or other spice oils that would irritate the bird's eyes. (Banders should carry one 2" diameter tube in breeding season to accommodate fat, egg-laying shrikes). Traps and tubes are carefully sanded and smoothed so there are no sharp edges or protruding wires.

Field Work Results

In 1991, I moved to Colorado Springs, CO, where I obtained Federal and State permits to catch and band wild birds. Since I already had the tools and knowledge to catch shrikes, I decided to focus on catching shrikes in Colorado. During mild winters, a few loggerhead shrikes can be found on Colorado's plains. Northern shrikes (*Lanius excubitor*) may occasionally be found on the plains and in suburbs as well. Weather permitting, I spent time in the field every month of the year. Beginning in March and April, I started catching early migrants. All these were adults and second-year birds in varying stages of molt. Then one late February morning, I caught a young bird that I could only age as hatching-year. Some juvenal feathers were retained on the head; flight feathers and rectrices were still sheathed at the base, indicating that the bird was less than 40 days old. Molt of secondary coverts had not yet begun. Under-wing feathers were sparse; wing and tail measures were short by 5 or 6 millimeters. I was stunned. Where had this bird been hatched? Certainly not on the high plains of Colorado. This capture encouraged me to return promptly to my field route, where during the next 2 weeks I caught 2 more similarly-plumaged birds with retained juvenal feathers on the head (Fig. 1). I also caught the usual second-year and after-second-year migrating shrikes.

In the winters of 2010 and 2011, I obtained state and federal permission to band birds in Texas, so I started out in early January for a 2 week banding trip. There I found lots of wintering shrikes. On 2 separate days, I caught and banded 33 shrikes with my trusty little traps. In 2011, I was lucky enough to recapture a shrike banded by Amy Chabot from her previous Texas work. Then, in Texas, early-January 2012, I caught a hatching year shrike. It seemed independent of parents, had retained juvenal feathers on the upper back and head, some remaining yellow gape at the corners of the mouth, and had the same molt characteristics as those mysterious migrants I'd caught in Colorado. A few hours later, I caught another shrike with the same characteristics. These captures were decidedly unique.

Significantly, birders in Texas often find nests of loggerhead shrikes in late February and March, indicating that resident shrikes breed early in the south. A shrike enthusiast in Florida found a nest of begging nestlings near the eastern coast of Florida in mid-January. Dr. Reuven Yosef, who did seminal shrike research at Florida's Archbold Biological Research Station during the 90s, caught newly-fledged shrikes during his winters there (pers. comm.). Since aging these birds was not part of his research thesis, they were not considered significant.

Conclusion

I have come to realize that over the years, I have caught numbers of these age-suspect birds in Colorado. Some were slightly older, with a few molted secondary coverts, but without any feather wear, fading or secondary molt. A few even had retained juvenal feathers on the head. These birds are readily distinguishable from previous-summer-hatched second-year shrikes, which have clearly molted secondary coverts, show primary feather wear, fading of retained secondaries, and varying numbers of molted inner secondaries.

These observations of winter nesting are anecdotal, but may support the idea that some migrant shrikes breed during favorable winters in southern states. These winter hatchlings then migrate out with other migrant shrikes, and subsequently breed in summer habitats. It has been shown that a few summering locations (south-eastern Alberta and southern Saskatchewan) have experienced an increase in breeding shrikes, which is unusual for this declining species (Amy Chabot, pers. comm.). Obviously additional field study is needed, along with stable isotope analysis in feathers of young shrikes showing where these young birds were hatched. In springtime, shrike banders everywhere should be on the lookout for birds of questionable age. Aside from noting that the age is "unknown", the Banding Lab has no category for winter-hatched birds that may be only a few months old. In-hand examination, plus looking for telltale signs of newly fledged birds will lend further support to this hypothesis.

References

Chabot, A.A. 2011. The impact of migration on the evolution and conservation of an endemic North American passerine: Loggerhead Shrike (*Lanius ludovicianus*). Unpublished PhD., Queen's University.

Craig, SH. 1997. What goes around – gets caught! An improved trap for shrikes. *North American Bird Bander* 22: 124-125.

Miller, AH. 1931. Systematic revision and natural history of the American Shrikes (*Lanius*). *University of California Publications* in Zoology 38: 11-242.

Sustaita, D, Hertel F. 2010. *In vivo* bite and grip forces, morphology and prey-killing behavior of North American accipiters (Accipitridae) and falcons (Falconidae). *Journal of Experimental Biology* 213: 2617-2628.

Yosef, R. 1996. Loggerhead Shrike (*Lanius ludovicianus*). In: Poole, A, Gill, F, eds. *The Birds of North America*. Philadelphia: The Birds of North America, Inc, 1-27.

Figure 1. A Hatching Year Loggerhead Shrike (*Lanius ludovicianus*) caught and banded on 1 April 2011 on the plains east of Colorado Springs. Photo:Susan Craig.

European Journal of Ecology, 2024, 25-29

LOGGERHEAD SHRIKE (*LANIUS LUDOVICIANUS*) IN THE GULF COAST JOINT VENTURE REGION, USA: STATUS, HABITAT DELIVERY, AND MONITORING

William G. Vermillion[1], Stephen J. DeMaso[1], Mark W. Parr[1,2]

[1]*U.S. Fish and Wildlife Service, Gulf Coast Joint Venture, USGS Wetland and Aquatic Research Center, 700 Cajundome Blvd., Lafayette, LA 70506, USA*
[2]*U.S. Fish and Wildlife Service, Branch of Conservation Science, Training Division, National Conservation Training Center, 698 Conservation Way, Shepherdstown, WV 25443, USA*
**Corresponding author* e-*mail*: william_vermillion@fws.gov

Abstract.

The United States Gulf of Mexico coastal region provides important habitat for resident and wintering Loggerhead Shrikes (Lanius ludovicianus); however, as in most of the species' range populations have declined since the 1970's. Possible factors in declines include loss and alteration of grassland habitat, changes in farming practices, contaminants, and introduced competitor species. The Gulf Coast Joint Venture (GCJV) is a regionally based, biologically driven, landscape-oriented volunteer partnership of private, state, and federal conservation organizations dedicated to the delivery of habitat important to priority bird species. Loggerhead Shrike is a priority species for the GCJV partnership. The GCJV partnership's Coastal Grassland Restoration Incentive Program (C-GRIP) provides financial incentives to private landowners for conducting habitat treatments that address the greatest limiting factors to provide suitable grassland bird habitat on their property. Implemented in 2018, the C-GRIP program is a way for the GCJV to deliver bird habitat to meet its planning objectives for Loggerhead Shrike and other grassland birds. GCJV staff have developed a monitoring protocol to assess the performance of the C-GRIP habitat delivery program. The monitoring objective is to evaluate whether or not the C-GRIP program is effective in providing a relative increase in the density (number/acre) of priority grassland bird species in focal delivery areas versus control areas over a 10-year period. Monitoring commenced in 2022. A total of 21 Loggerhead Shrikes were detected in 2022, 14 on treatment survey routes and 7 on control routes. In 2023, 16 Loggerhead Shrikes were detected, 10 on treatment survey routes and 6 on control routes. GCJV staff plan on conducting surveys on these routes through 2032.

Key words: *Loggerhead Shrike, Gulf Coat Joint Venture, habitat delivery, monitoring*

Introduction

North American grassland bird abundance has declined by greater than fifty percent between 1970-2017 (Rosenberg et al. 2019), and specifically, Loggerhead Shrikes (*Lanius ludovicianus*) have declined by 74 percent between 1970-2014 (Rosenberg et al. 2016). Loggerhead Shrike was formerly a common resident and wintering species along the northern United States (U.S.) Gulf of Mexico region (Lowery 1974, Imhof 1976, Remsen et al. 1991, Turcotte and Watts 1999). Remsen et al. (1991) estimated 4,366 resident Loggerhead Shrikes in a 1,191 square mile (~3,085 square kilometer) study area, and contrasted that relative abundance with declines in other parts of the United States noted by researcher in the 1980's. However, as early as 1960, Imhof (1976) noted declines in Alabama. Between 1966 – 2019, populations in the Gulf of Mexico coastal states of Texas, Louisiana, and Mississippi declined by approximately two percent per year (Sauer et al. 2020). As in other parts of the species' range, the possible reasons for declines are many, but it is not clear which ones are most significantly driving declines.

Loss or significant alteration of Loggerhead Shrike breeding, wintering, and migration habitat is probably an important factor linked to population declines along the U.S. Gulf of Mexico coast. Of an historic 12 million acres (~5 million hectares) of coastal prairie in the states of Texas and Louisiana, less than one percent remain, the majority converted to row-crop agriculture, exotic grass pasture or human development (NOAA 2023, TCPI 2023). Suppression of historic fire regimes have enabled invasive woody species to colonize grasslands and savannas, and intensive cattle (*Bos taurus*) grazing has resulted in reduced plant species and habitat structural diversity (Allain et al. 1999). The changes in farming practices that are believed to have contributed to declines in Northern Bobwhite (*Colinus virginianus*) have likely affected Loggerhead Shrikes as well. Farming practices that favor large patches of uniform crops often eliminate fence row habitat that provides perches and nesting habitat (Brennan et al. 2005). Use of agricultural habitat and position in the food chain potentially puts Loggerhead Shrikes at risk to exposure to pesticides (Fraser and Luukkonen 1986). The role of contaminants in the species' decline remains uncertain, yet there are concerns that arthropod prey availability is significantly reduced through pesticide use (Yosef 1994, 2020).

While some research indicates that breeding habitat is not limited for Loggerhead Shrikes (Brooks and Temple 1990, Lymn and Temple 1991) the juxtaposition of habitat may have changed in a way that limits habitat suitability. In South Carolina, Froehly et al. (2018) found that Loggerhead Shrike occupancy was best predicted by the amount of pasture within a 1-km radius of survey points, with predicted occupancy ranging from two percent when there was no pasture within a 1-km radius to 98 percent when there was 43 percent or more pasture within that radius. Their results suggested that only eight percent of the South Carolina coastal plain was occupied by breeding Loggerhead Shrikes.

Wintering habitat along the Gulf of Mexico coast has changed as well. Crouch et al. (2019) examined habitat use by wintering Loggerhead Shrikes and found that medium-and high-intensity human development had increased by over 15 percent in their south Texas study area between 2001 – 2011. This decrease in winter habitat (and presumed overwinter mortality impacts) may be a factor in continental shrike declines (Temple 1988). With increased human development comes increased vehicular traffic, and shrikes are vulnerable to vehicle strikes due to habitat use and flight patterns (Yosef 2020). Flickinger (1995) found that shrikes were over-represented relative to their overall abundance in a Texas highway mortality study.

The impacts of fire ants (*Solenopsis invicta*) on Loggerhead Shrikes and other birds have been debated. Introduced into the Unites States in the 1930's, the ant has spread into at least 14 states and Puerto Rico and affects more than 367 million acres (148 million ha) of land (USDA 2023). Fire ants are aggressive predators and feed on most of the same food items preferred by shrikes, including grasshoppers, crickets, beetles, small mammals, and birds. Fire ant impacts on wildlife remains a controversial topic, and Yosef and Lohrer (1995) urged caution, as the impacts of broad-scale pesticide applications in an effort to control fire ants may be more damaging to Loggerhead Shrikes than the ants' impacts. However, Allen et al. (2001) found insect abundance, species richness and diversity, and Loggerhead Shrike abundance was greater on sites treated with fire ant baits than on control sites. Similarly, Morrow et al. (2015) found evidence that fire ants indirectly affected Attwater's Greater Prairie-Chicken (*Tympanuchus cupido attwateri*) survival by suppressing invertebrate abundance and posited that the same mechanism could be contributing to declines of other insectivorous species.

Due to the importance of the U.S. Gulf of Mexico coast to the species and because of the declines described above, Loggerhead Shrike was selected as a priority species for conservation planning and habitat delivery by the Gulf Coast Joint Venture partnership. The Gulf Coast Joint Venture (GCJV) is one of over twenty voluntary partnerships in North America dedicated to the conservation of priority bird species habitats. Identified in the North American Waterfowl Plan (U.S. Department of the Interior and Environment Canada, 1986) bird habitat Joint Ventures are coalitions of private and governmental organizations, able to pool resources and work across political boundaries to address priority avian research and habitat management projects. The GCJV region encompasses the coastal portion of the U.S. states of Texas, Louisiana, Mississippi, and Alabama (Figure 1). Staff use an adaptive management framework to step down the North American continental bird plans' population objectives to the GCJV region, develop population-habitat models to determine how much and what kind of habitat is needed to achieve the objectives, work with partner agencies to deliver habitat, monitor outcomes, and address key uncertainties identified in the forementioned population-habitat models.

Because the majority of the GCJV region is privately-owned, habitat objectives for Loggerhead Shrikes and other priority grassland bird species cannot be achieved solely on public wildlife refuges and management areas. In response to the need for improved grassland habitat on private lands, the GCJV partnership developed and began implementing the Coastal Grassland Restoration Incentive Program (C-GRIP) in 2018. C-GRIP provides financial incentives to private landowners for conducting habitat treatments that improve the suitability of grassland bird habitat on their property. C-GRIP is a voluntary program that reimburses private landowners a set payment rate for identified practices that generally fall into the categories of brush management, prescribed burning, native grass and forb planting, and prescribed grazing.

C-GRIP is currently being implemented in ten focal areas in Texas and Louisiana (Figure 2). To be eligible for the program, treatment areas must be at least partially in a focal area, privately-owned, and at least 25 acres in size (approximately 10 hectares). The landowner is required to work with a project manager representing one of the GCJV partner agencies to identify the appropriate management actions for improving grassland bird habitat on the treatment area. Eligible treatments are determined by a committee of GCJV staff and partner agency representatives, selected from a list of practices developed for the U.S. Department of Agriculture's (USDA) Environmental Quality Incentives Program (USDA 2023). The participating landowner must be committed to maintaining the improved habitat state for at least 5 years following project completion.

As of December 2023, 68,351 acres (27,661 hectares) and 625 acres (253 hectares) had been enrolled in C-GRIP in Texas and Louisiana, respectively. To assess the effectiveness of C-GRIP in providing habitat for priority grassland bird species, GCJV staff developed and implemented a monitoring methodology, the C-GRIP Species Programmatic Survey. The monitoring objective of the C-GRIP Species Programmatic Survey (C-GRIP Survey) is to evaluate if the C-GRIP program is effective in providing a relative (versus controls) increase in the density (number/acre) of grassland priority bird species over a 10-year period. If the population trend is more positive on the focal treatment areas (relative to controls) or if the focal area trend line is flat or slightly negative, and the control area trend line is significantly more negative over a 10-year period, the C-GRIP program would be considered successful. In addition to Loggerhead Shrike, priority species for the C-GRIP Survey are Mottled Duck (*Anas fulvigula*) and Northern Bobwhite. An additional 5 species of grassland birds are also monitored: Scissor-tailed Flycatcher (*Tyrannus forficatus*), Lark Sparrow (*Chondestes grammacus*), Eastern Meadowlark (*Sturnella magna*), Painted Bunting (*Passerina ciris*), and Dickcissel (*Spiza americana*). The monitoring metric for the C-GRIP Survey is the density estimate for the bird species listed above in focal and control areas. To date, all C-GRIP Survey monitoring has been conducted in Texas. Monitoring is anticipated to begin in Louisiana in the next few years.

Figure 1. Gulf Coast Joint Venture Region

Methodology

The C-GRIP Survey employs point-transects, a form of distance sampling that account for imperfect detectability in density estimates (Buckland et al. 2001). Point count stations are located along a designated route or transect. Twenty survey routes, 2 within each of 5 focal areas (treatment) and 2 outside each area (control) were established on secondary and tertiary roads in or adjacent to the GCJV's Texas Mid-Coast Initiative Area. Each route measures at least 14.5 miles (23.3 kilometers) and contains 30 survey points separated by at least 0.5 miles (0.8 kilometers).

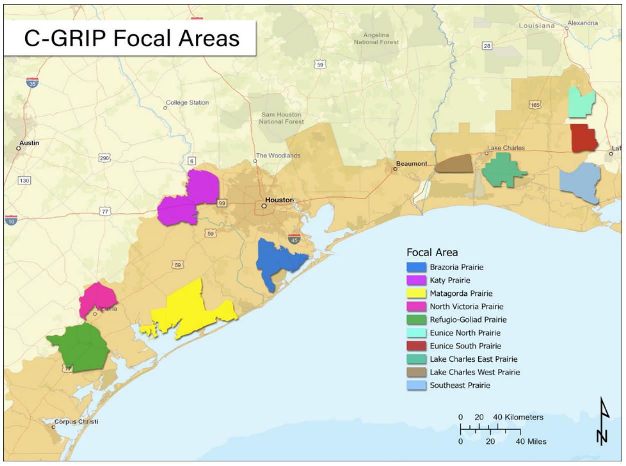


Figure 2. C-GRIP Focal Areas

The surveys are conducted between May 15 and June 10 of each year to coincide with the breeding season of the priority grassland bird species. Survey methodology is similar to the North American Breeding Bird Survey (BBS, U.S. Geological Survey 2023). Surveys began one half hour prior to sunrise. A vehicle Global Positioning System unit with a preloaded route and points is used to navigate. At each survey point, surveyors record aural and visual detections of priority species and record the minute (1,2,3,4, or 5) the bird was detected, whether the detection was by sound, sight or both, and the distance from the surveyor to the detected individual. Detection distances are estimated using binoculars with built-in rangefinders. Individual birds are only recorded once. If an adult bird is attending juveniles, only the adult bird is counted.

Additional variables are recorded at each point. These include date, survey start and end times, type of road, ambient temperature, percent cloud cover, estimated Beaufort scale wind speed (National Weather Service 2023), and the amount of noise (besides bird songs or wind) at the point, ranging from 0, silent to 3, constant noise. Cardinal directions (i.e., compass bearings) are recorded on the left and right sides of the vehicle, along with type and percentages of vegetation cover. If grass or non-crop herbaceous vegetation is present, surveyors estimate whether the majority is equal to or greater than 8 inches (20.3 centimeters) in height. This height is estimated to be a minimum to provide sufficient cover for ground-nesting grassland birds. A photograph is taken of vegetation conditions on both sides of the vehicle.

Point data is recorded on iPads (Apple, Incorporated) using the ArcGIS Survey123 (Environmental Systems Research Incorporated, ESRI) platform. This platform allows users to develop custom forms for data collection. Data can be collected in the field and uploaded to databases in real time, or if no internet connection is available, data can be stored on the device and then uploaded later. To date, surveys have been implemented by GCJV staff, USFWS biologists, and staff of the non-profit conservation group Pheasant Forever/Quails Forever, Incorporated. GCJV staff provide a one-day workshop annually for surveyors that includes information on safety, survey methodology, equipment, and species identification.

Results

Two years of data have been collected. GCJV staff intend to conduct surveys through 2032. No formal analyses have been conducted to date, but some general observations can be made. A total of 37 shrikes have been observed during the 2022 and 2023 surveys. Twenty-four (65%) shrikes were detected on treatment routes, and 13 (35%) on control routes. Fifty-seven percent of all shrikes were detected visually, 24% by their calls, and 19% by both visual and by calls. Thirty-eight percent of birds were observed during the first minute (minute 0-1) of the five-minute observation period, followed by 19% during minute 3-4, 16% during minute 1-2, and 13.5% during minutes 2-3 and 4-5, respectively.

The average percent of grass cover at survey points where shrikes were detected was 42%, average shrub cover (≤ 2 meters tall) was 8% and average woody cover (> 2 meters tall) was approximately 4%. At 54% of survey points where shrikes were detected, half or more of grass and herbaceous vegetation present was ≥8 inches tall (~20 cm), and at 46% of sites with shrikes detected all grass or herbaceous vegetation present was < 8 inches tall. Fifty-one percent of points with detected shrikes included some sort of agricultural crop field; 49% of points had no agricultural crop fields.

Discussion

After two years of data collection, detections on control versus treatment routes are comparable. Because habitat on treatment and control routes are similar and C-GRIP practices have only been implemented since 2018, these results are not surprising.

Loggerhead Shrike numbers were the third lowest of monitored species. Relative abundance indices generated from BBS routes in the same region suggest that from 0 – 5 birds are observed per 25-mile survey route (Sauer et al. 2020), so C-GRIP results are similar. While there are potential sources of bias from sampling avian populations only from roadsides (Bart et al. 1995, Hanowski and Niemi, 1995, Keller and Scanlan 1999), there is little evidence that Loggerhead Shrikes select for habitat away from roadsides. Studies have shown that the species commonly uses powerlines, fences, and other man-made structures along roads (Crouch et al. 2019, Donahue et al. 2021).

Meaningful results will require more years of data. GCJV staff and partners intend to monitor these routes and points through 2032, but it is possible that some routes will have to be modified due to safety concerns or increases in noise that significantly impact aural detections.

As a group, grassland birds have declined more so than any other group of birds in North America since 1970 (Rosenberg et al. 2019). Because a large proportion of grassland habitat in North America is on private or tribal lands (JV8 Central Grasslands Conservation Initiative, 2023) it is imperative that programs such as C-GRIP provide incentives that enable sustainable ranching and grazing while improving habitat for declining grassland bird species.

References

Allain, L., M. Vidrine, V. Grafe, C. Allen, and S. Johnson. 1999. Paradise lost? The coastal prairies of Louisiana and Texas. U.S. Fish and Wildlife Service/U.S. Geological Survey publication. 39 pp.

Allen, C.R., R.S. Lutz, T. Lockley, S.A. Phillips, Jr., and S. Demarais. 2001. The non-indigenous ant, *Solenopsis invicta*, reduces Loggerhead Shrike and native insect abundance. Journal of Agricultural and Urban Entomology 18(4):249 -250.

Bart, J., M. Hofschen, and B.G. Peterjohn. 1995. Reliability of the Breeding Bird Survey: effects of restricting surveys to roads. The Auk 112(3):758-761.

Brennan, L., S. DeMaso, F. Guthery, J. Hardin, C. Kowaleski, S. Lerich, R. Perez, M. Porter, D. Rollins, M. Sams, T. Trail, and D. Wilhelm. 2005. Where have all the quail gone? The Texas quail conservation initiative: a proactive approach to restoring quail populations by improving wildlife habitat. Texas Parks and Wildlife Publication PWD RP W7000-1025.

Brooks, B.L., and S.A. Temple. 1990. Dynamics of a Loggerhead Shrike population in Minnesota. Wilson Bulletin 102:441-450.

Buckland, S.T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford University Press, Oxford, United Kingdom

Crouch, C.G., A.J. Flores, A. Krainyk, L.A. Brennan, D.B. Wester, E.D. Grahmann, R.H. Benson, F. Hernández, and J.F. Kelly. 2019. Comparative habitat use of wintering American Kestrels and Loggerhead Shrikes along south Texas roadways. Southeastern Naturalist 18(2):240-255.

Donahue, E.R., K.J. Kracir, L.C. Bryant, R. Raibley, J.L. Wessels, J. Youtz, and T.J. Boves. 2021. Non-breeding behavior and diet of Loggerhead Shrikes in an intensive agricultural region. Southeastern Naturalist 20(3):427-447.

Flickinger, E.L. 1995. Loggerhead shrike fatalities on a highway in Texas. Pages 67-69 *in* R. Yosef and F.E. Lohrer, eds. Shrikes (*Laniidae*) of the world: biology and conservation. Proceedings of the Western Foundation of Vertebrate Zoology 6(1):1-343.

Fraser, J.D., and D.R. Luukkonen. 1986. The loggerhead shrike. Pages 933-941 in R.L. DiSilvestro, editor. Audubon Wildlife Report 1986. Academic Press, New York.

Froehly, J.L., A.K. Tegeler, C.M. Bodinof Jachowski, and D.S. Jachowski. 2018. Effects of scale and land cover on Loggerhead Shrike Occupancy. The Journal of Wildlife Management 83(2):426-434.

Hanowski, J.M. and G.J. Niemi. 1995. A comparison of on- and off-road bird counts: do you need to go off road to count birds accurately? Journal of Field Ornithology 66(4):469-483.

Imhof, T.A. 1962. Alabama birds. Univ. of Alabama Press, Tuscaloosa, AL. 591 pp.

JV8 Central Grasslands Conservation Initiative. 2023. JV8 Central Grasslands Conservation Initiative implementation strategy – 2021 to 2024 https://jv8.org/wp-content/uploads/2022/04/JV8-Central-Grasslands-Conservation-Initiative-Implementation-Strategy-%E2%80%93-2021-to-2024-Final.pdf Accessed 19 December 19, 2023.

Keller, C.M.E. and J.T. Scallan. 1999. Potential roadside biases due to habitat changes along Breeding Bird Survey routes. The Condor 101:50-57.

Lowery, G.H., Jr. 1974. Louisiana Birds. Louisiana Wild Life and Fisheries Commission, Louisiana State University Press. 651 pp.

Lymn, N., and S. Temple. 1991. Land-use changes in the Gulf Coast region: links to declines in Midwestern Loggerhead Shrike populations. Passenger Pigeon 53:315-325.

Morrow, M.E., R.E. Chester, S.E. Lehnen, B.M. Drees, and J.E. Toepfer. 2015. Indirect effects of red imported fire ants on Attwater's Prairie-Chicken brood survival. The Journal of Wildlife Management 79(6):898-906.

National Oceanic and Atmospheric Administration, Office for Coastal Management. 2023. C-CAP Land Cover Atlas. coast.noaa.gov/digitalcoast/tools/lca.html. Accessed 21 August 2023.

National Weather Service. 2023. Beaufort Wind Scale https://www.weather.gov/mfl/beaufort Accessed 15 December 15, 2023.

Remsen, J.V., Jr., M.M. Swan, S.W. Cardiff, and K.V. Rosenberg. 1991. The importance of the rice-growing region of south-central Louisiana to winter populations of shorebirds, raptors, waders, and other birds. Journal of Louisiana Ornithology 1(2):35-47.

Rosenberg, K.V., A.M. Dokter, P.J. Blancher, J.R. Sauer, A.C. Smith, P.A. Smith, J.C. Stanton, A. Panjabi, L. Helft, M. Parr, and P.P. Marra. 2019. Decline of the North American avifauna. Science 366:120-124.

Rosenberg, K.V., J.A. Kennedy, R. Dettmers, R.P. Ford, D. Reynolds, J.D. Alexander, C.J. Beardmore, P.J. Blancher, R.E. Bogart, G.S. Butcher, A.F. Camfield, A. Couterier, D.W. Demarest, W.E. Easton, J.J. Giocomo, R.H. Keller, A.E. Mini, A.O. Panjabi, D.N. Pashley, T.D. Rich, J.M. Ruth, H. Stabins, J. Stanton, and T. Will. 2016. Partners in Flight landbird conservation plan: 2016 revision for Canada and continental United States. Partners in Flight Science Committee. 119 p.

Sauer, J.R., W.A. Link, and J.E. Hines. 2020. The North American breeding bird survey, analysis results 1966-2021: U.S. Geological Survey data release, http://doi.org/10.5066/P96A7675 Accessed 12 December 2023.

Temple, S.A. 1988. What's behind long-term declines in some breeding bird populations? Passenger Pigeon 50:133-138.

Texas Coastal Prairie Initiative. 2023. Saving Prairie Saving Prairie — Texas Coastal Prairie Initiative (prairiepartner.org) Accessed 12 December 2023.

Thomas, L., S.T. Buckland, E.A. Rexstad, J.L.Laake, S. Strindberg, S.L. Hedley, J.R.B. Bishop, T.A. Marques, and K.P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47:5-14. DOI:0.1111/j.1365-2664.2009.01737.x

Turcotte, W.H., and D.L. Watts. 1999. Birds of Mississippi. Mississippi Department of Wildlife, Fisheries, and Parks, University Press of Mississippi, Jackson. 455 pp.

U.S. Department of Agriculture, Animal and Plant Health Inspection Service. 2023. Imported Fire Ants. Available: https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/imported-fire-ants/CT_Imported_Fire_Ants#:~:text=Today%2C%20IFA%20infest%20more%20than,Texas%2C%20Virginia%20and%20Puerto%20Rico. Accessed 17 August 2023.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2023. Environmental quality incentives program https://www.nrcs.usda.gov/programs-initiatives/eqip-environmental-quality-incentives Accessed 12 December 2023.

U.S. Department of the Interior and Environment Canada. 1986. North American waterfowl management plan. 19 pp. https://nawmp.org/sites/default/files/2018-01/1986%20OriginalNAWMP.pdf Accessed 12 December 2023.

U.S. Geological Survey. 2023. North American Breeding Bird Survey https://www.pwrc.usgs.gov/bbs/ Accessed 15 December 2023.

Yosef. R. 1994. Evaluation of the global decline in the true shrikes (family Laniidae). The Auk 111:228-233.

Yosef, R. 2020. Loggerhead Shrike (*Lanius ludovicianus*), version 1.0. In Birds of the World (A.F. Poole and F.B. Gill, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi-org.fwslibrary.idm.oclc.org/10.2173/bow.logshr.01 Accessed 9 January 2024.

Yosef, R., and F.E. Lohrer. 1995. Loggerhead Shrikes, red fire ants and red herrings? The Condor 97:1053-1056.

European Journal of Ecology, 2024, 30-42

AN INITIAL DESCRIPTION OF THE FECAL MICROBIOME OF WINTERING NORTHERN SHRIKES *LANIUS BOREALIS*

Eric C. Atkinson[1, 2], Abbie Valine[3], Kinley E. Bollinger[4]

[1]Biology Department & INBRE, Northwest College, Powell, Wyoming, USA, 82435, University of Wyoming, & Northern Rockies Conservation Cooperative, avesgye@gmail.com
https://orcid.org/0000-0002-5968-2371
[2] corresponding author eric.atkinson@nwc.edu
[3]Hawk Ridge Bird Observatory, P.O. Box 3006, Duluth, Minnesota, USA, 55803.
[4]Biology Department & INBRE, Northwest College, Powell, Wyoming, USA, 82435.

Abstract.

This study aimed to broaden our understanding of the natural history of Northern Shrikes by analyzing the gut microbiome of wintering individuals in northern Minnesota using fecal samples from 19 individuals. Bacterial DNA was extracted and sequenced using Illumina metabarcoding subsequently processing these reads via QIIME2. The microbiome was dominated by the phyla Proteobacteria (88.8%) and Firmicutes (9.9%), two phyla often found in high proportions in avian gut samples. However, the preponderance of Proteobacteria is noteworthy but may be explained by the sample from one individual, an adult male. Notable genera included Rickettsiella, Clostridioides, and Lactobacillus. We found no statistically significant differences in microbiome evenness and diversity between sexes or age groups. This study provides one of the first insights into the microbiome of Northern Shrikes, contributing valuable data on this understudied species. Further research is recommended to investigate microbiome variations across Laniidae geographically, with respect to diet, and among different habitats.

Keywords: *Northern Shrike;* Lanius borealis*; winter; microbiome; metabarcoding; QIIME2; fecal microbiome*

Introduction

Between 1970 and 2017, populations of birds breeding in North American Arctic tundra have declined nearly 25% (Rosenberg et al. 2016). The estimated loss of Northern Shrikes *Lanius borealis* amounts to over 96000 individuals of an estimated continental population during this time period of 400000 (100000-700000 estimated range) individuals. Clearly, along with Loggerhead Shrikes *L. ludovicianus*, these predatory songbirds are suffering greatly, a family-wide trend noted many years ago following the convening of the 1st International Shrike Symposium (Yosef and Lohrer 1995). Furthermore, thirty-years following that first symposium little information yet exists on the natural history, demographic parameters, and population trends of Northern Shrikes breeding across northern Canada and Alaska as this species breeds in difficult to access locations and habitats (riparian zones along Arctic and subarctic rivers flowing through tundra and muskeg bogs along the ecotone of the boreal forest and this tundra), has likely never been common, and is labor intensive to capture on the wintering grounds spending its time in open landscapes occupying large winter territories (Atkinson 1993, Atkinson and Cade 1993). Northern Shrike wintering numbers are cyclic with low predictability in site occupancy from year to year (Rimmer. and Darmstadt 1996, Atkinson 1995, ECA unpub. data). That said, substantial efforts have been made to understand the natural history of American Northern Shrikes with often an unspoken desire to determine population status, trends, and limits to this wondrous bird that overlaps in its wintering range with the northern breeding range of its smaller congener the Loggerhead Shrike. These efforts include studies on metabolism (Paruk et al. 2015), morphology and sexual identification (Brady et al. 2009), breeding biology (Cade and Swem 1995), and hunting behavior (Atkinson 1997); see Paruk et al. (2020).

In this study, we wished to broaden the basic natural history information available for Northern Shrikes wintering in the northern United States. Specifically, with birds in-hand, an increased effort in sampling can generate large dividends including the characterization of the gut microbiome. Little information on the microbiome of shrikes exists (see Negruțiu et al. 2017, Hu et al. 2022) and the paucity of such information leaves a substantial gap in our understanding of this family. For that reason, we collected and sequenced the microbiome of all birds, including shrikes, captured, processed, and banded before release. Herein, we describe to our knowledge the first metabarcoding of wild Northern Shrikes in North America.

Materials and Methods

We captured Northern Shrikes in St. Louis, Aitkin, and Carlton Counties of northern Minnesota, USA (47°12’N, 92°37’W) between the months of December-March during the winters of 2021-2022 and 2022-2023.

We located shrikes via extensive driving through suitable habitat while scanning for shrikes hunting near roads.

Shrikes were trapped using a round potter trap (in the style of Craig, 1997) or small bal-chatri with a noose carpet baited with a live mouse. For each shrike, we recorded age, fat score, mass, wing chord, tail length, and extent of black on the outermost rectrix (r6). These morphometric measurements were used to determine sex of adults using the discriminant function equation developed by Brady et al. (2009). All birds were captured as part of a larger study on breeding origins and migratory movements of northern shrikes in the western Great Lakes region.

While in-hand, we aseptically recovered fecal samples immediately placing them in 2 ml cryovials which were then kept cool. Samples were refrigerated (4-8° C) and subsequently frozen at -80°C before extracting DNA. Staff at University of New Hampshire's Hubbard Center for Genome Studies (HCGS) extracted fecal DNA and amplified (PCR) on the v4/v5 gene of the ribosomal RNA with the primers 16S 515 (forward) and 16S 926 (reverse). Primers 515F–806R target the V4 region of the 16S SSU rRNA. Paired ends sequencing of 250 bases was performed on an Illumina NovaSeq SP PE 250. Following the QIIME2 metabarcoding pipeline (Kuczynski et al. 2012. Allali et al. 2017, Bolyen et al. 2019) we trimmed primers from the leading ends and truncated the sequences at positions 247 and 246 for the forward and reverse reads, respectively, based upon the 25th percentiles corresponding to Phred scores (a measure of quality) greater than 25 (Figure 1). To be clear, we followed the protocols outlined by Estaki et al. (2020 https://curr-protoc-bioinformatics.qiime2.org/)

As DNA sequences showed overall good quality post-trimming and truncating, we were satisfied that they represented the bacterial communities contained within Northern Shrike fecal samples well. Hence, we produced box and whisker plots of both bacterial taxonomic evenness (Pielou 1966) and bacterial diversity, testing for differences in age-class and sex in our sampled shrikes via QIIME2view (https://view.qiime2.org/). To be more comparable to ecological studies and to increase interpretability to ecologists of varied backgrounds we calculated Shannon Entropy that assesses disorder (Shannon and Weaver 1949) in addition to the more recently derived Faith's phylogenetic diversity (henceforth, Faith's PD) that accounts for phylogenetic tree branch length when calculating alpha diversity (Faith 1992). Furthermore, in this paper, we acknowledge the use of operational taxonomic units (OTU) rather than using the term 'species' to describe taxonomically identifiable organisms in our samples. We performed Kruskal-Wallace tests, within QIIME2, for differences between identified sex and age of the shrikes across Evenness, Shannon Entropy, and Faith's Phylogenetic PD.

RESULTS

We captured 37 Northern Shrikes and recovered fecal samples yielding extractable DNA from 19 individuals; five females, eight males, six unknown sex; six (HY and early SY) first-year birds and 13 birds greater than one-year of age.

The vast majority (99.8%) of bacterial types identified in Northern Shrike fecal material spanned four bacterial phyla as outlined in the taxa barplots depicted in Figure 2 and Figure 3. Phyla Proteobacteria contributed 88.8% of reads, Firmicutes 9.9%, Actinobacteriota 0.9%, and Desulfobacterota 0.2 (Figure 4). By far, most bacteria enumerated were of phylum Proteobacteria, a very diverse, ubiquitous, and common type of prokaryote.

At the genus-level, *Rickettsiella*, *Clostridioides*, *Sporosarcina*, and *Lactobacillus* predominated in the fecal samples (Figure 5, Table 1). *Rickettsiella*, an outlier, was only found in two shrikes.

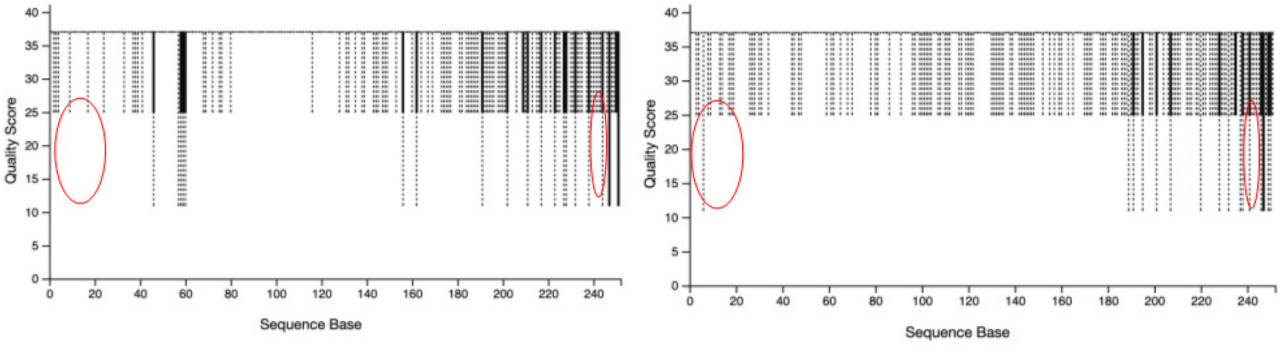


Figure 1. Quality plots of Forward Reads (top) and Reverse Reads (bottom). Areas of trimming (left on each graph) and truncation (right on each graph) are circled.

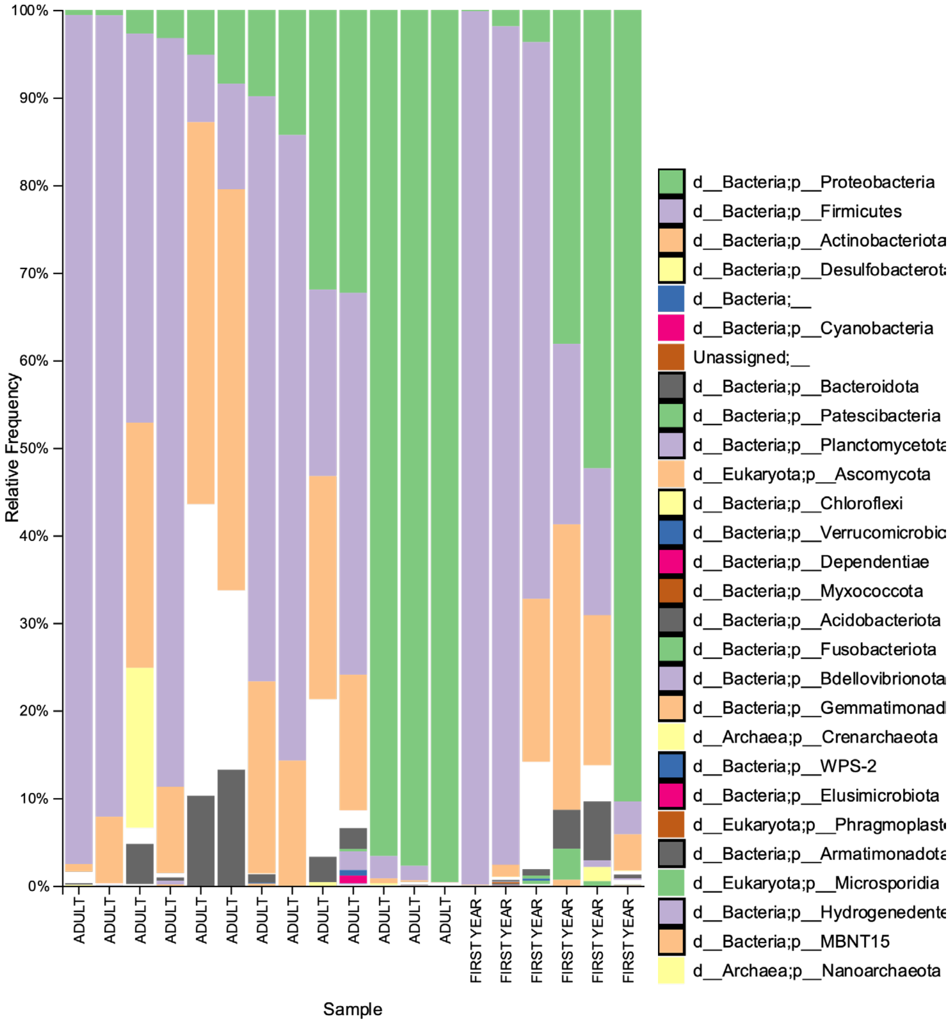


Figure 2. Taxa bar plot, level 2 (phylum) of bacterial (some Eukarya and Archaea) taxa sequenced from Northern Shrike fecal samples.

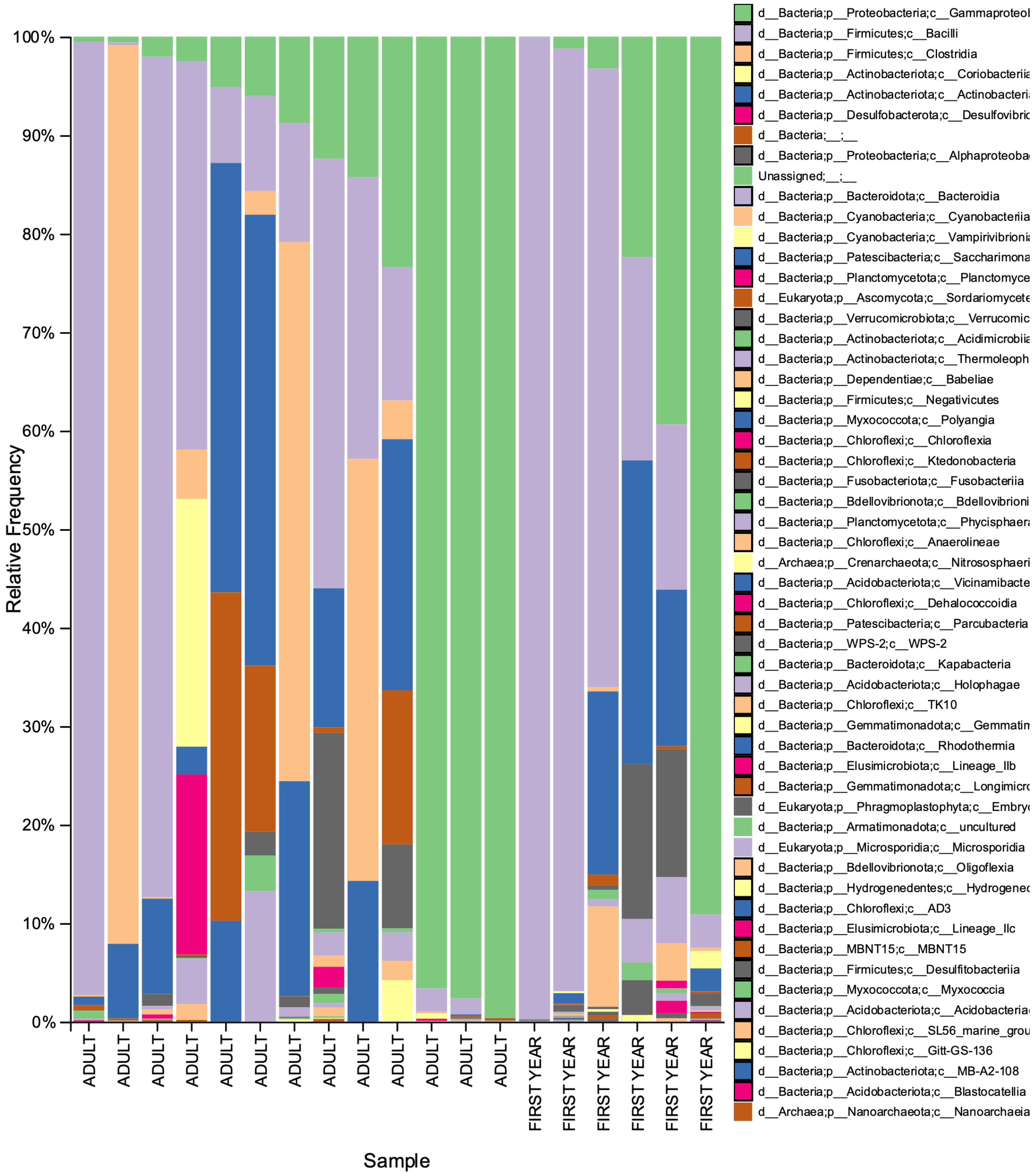


Figure 3. Taxa bar plot, level 3 (class) of bacterial (some Eukarya and Archaea) taxa sequenced from Northern Shrike fecal samples.

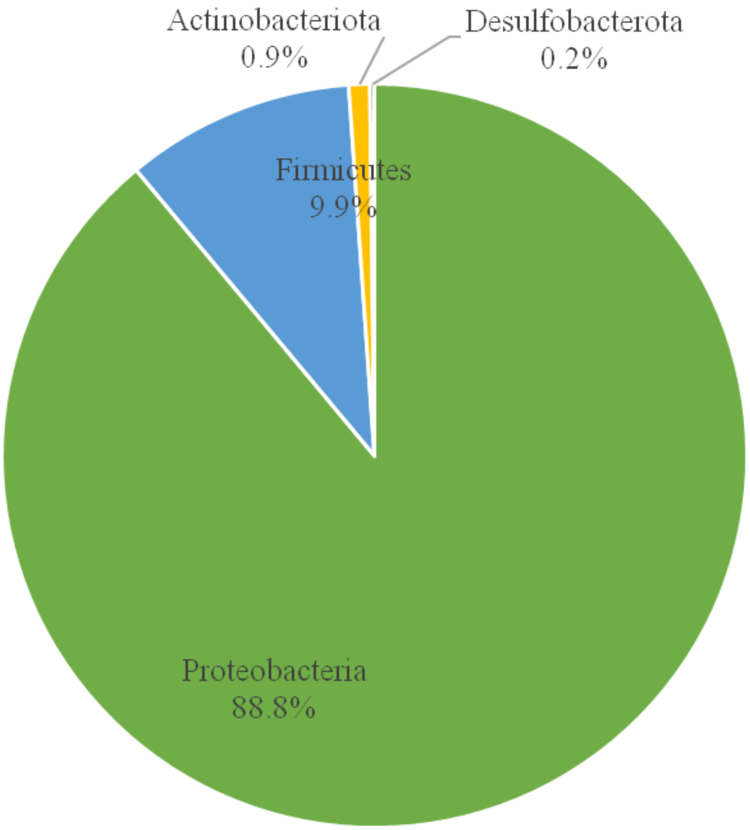


Figure 4. Proportional composition of four most common bacterial phyla sequenced from Northern Shrike fecal samples based upon number of reads.

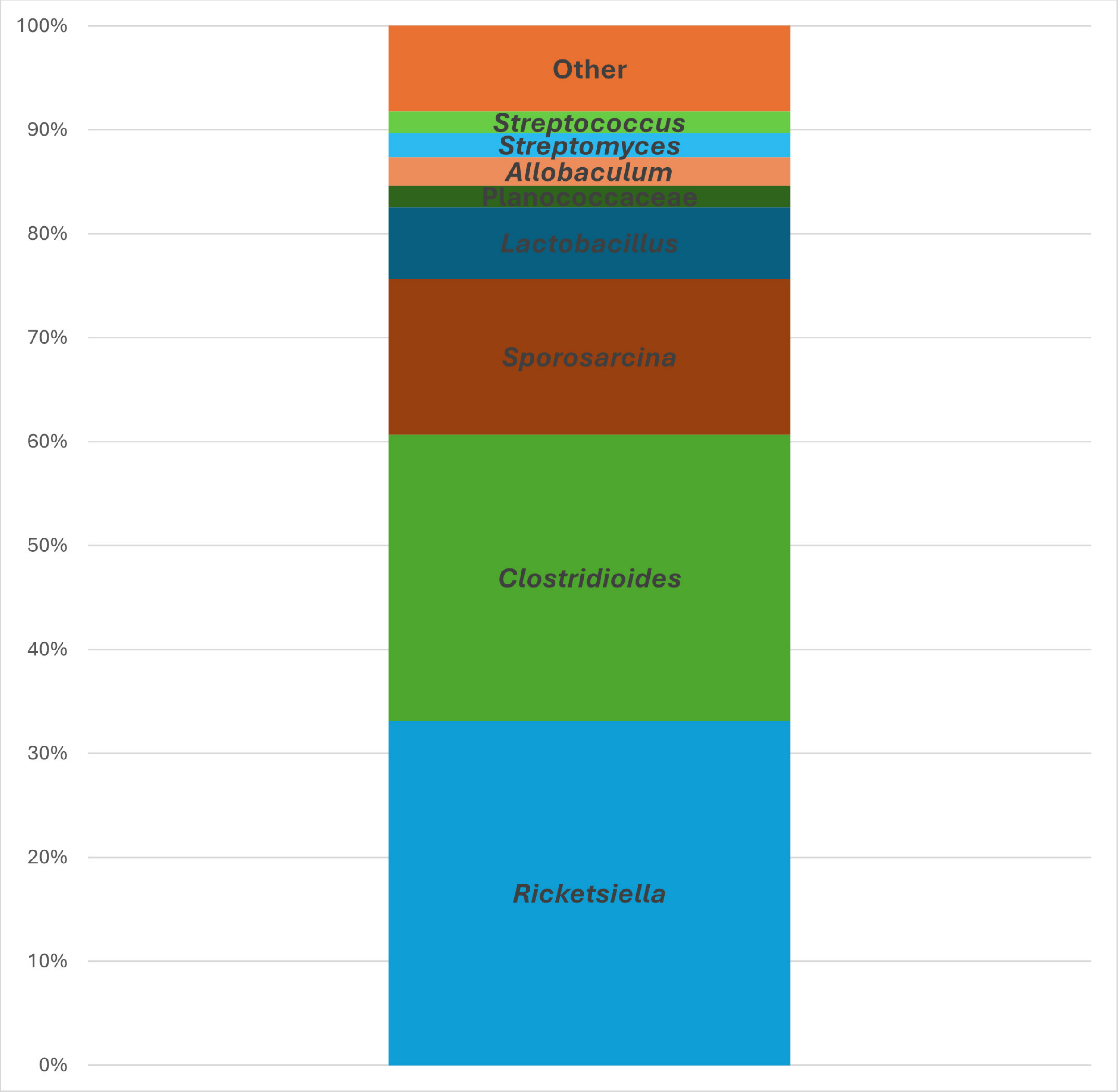
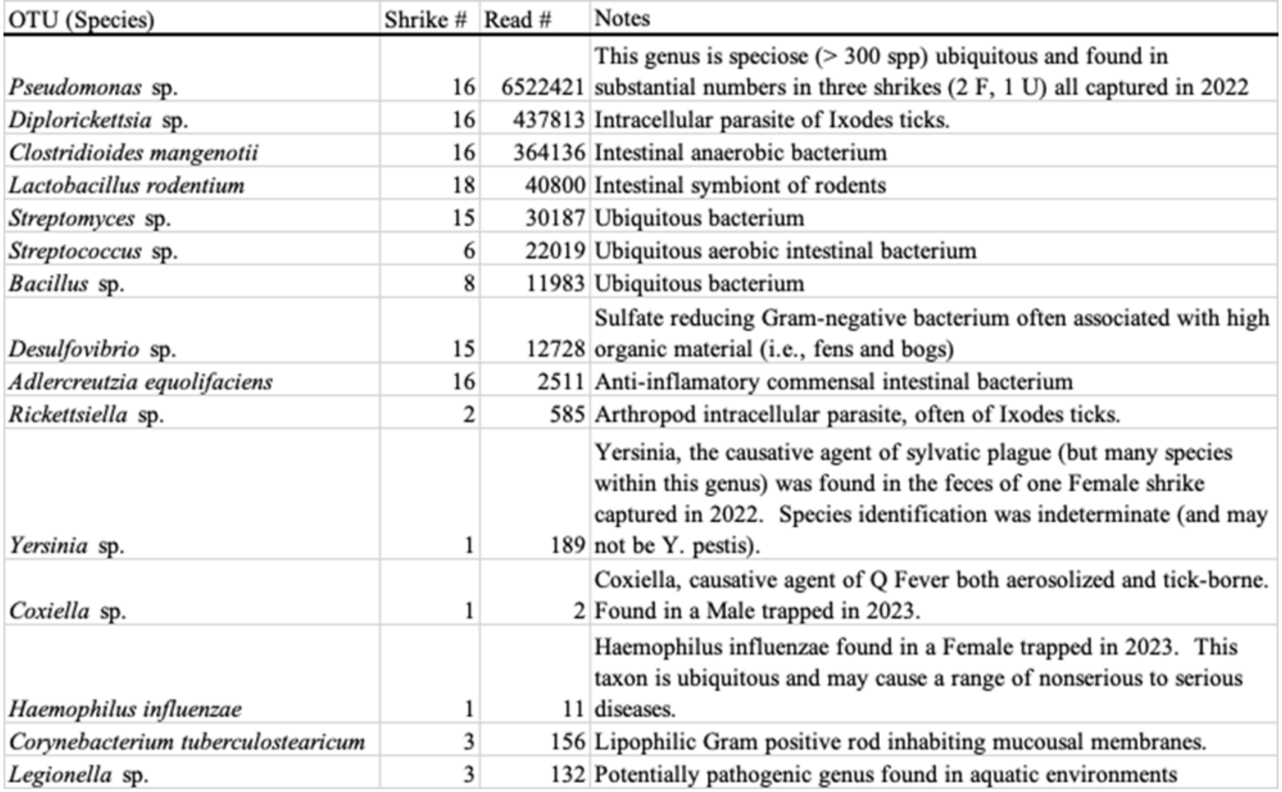


Figure 5. Proportional composition of most abundant bacterial genera sequenced from Northern Shrike fecal samples based upon number of reads.

Table 1. Some bacterial genera and/or species (OTUs) of interest. *n* = 19 Northern Shrikes.



OTU (Species)	Shrike #	Read #	Notes
Pseudomonas sp.	16	6522421	This genus is speciose (> 300 spp) ubiquitous and found in substantial numbers in three shrikes (2 F, 1 U) all captured in 2022
Diplorickettsia sp.	16	437813	Intracellular parasite of Ixodes ticks.
Clostridioides mangenotii	16	364136	Intestinal anaerobic bacterium
Lactobacillus rodentium	18	40800	Intestinal symbiont of rodents
Streptomyces sp.	15	30187	Ubiquitous bacterium
Streptococcus sp.	6	22019	Ubiquitous aerobic intestinal bacterium
Bacillus sp.	8	11983	Ubiquitous bacterium
Desulfovibrio sp.	15	12728	Sulfate reducing Gram-negative bacterium often associated with high organic material (i.e., fens and bogs)
Adlercreutzia equolifaciens	16	2511	Anti-inflamatory commensal intestinal bacterium
Rickettsiella sp.	2	585	Arthropod intracellular parasite, often of Ixodes ticks.
Yersinia sp.	1	189	Yersinia, the causative agent of sylvatic plague (but many species within this genus) was found in the feces of one Female shrike captured in 2022. Species identification was indeterminate (and may not be Y. pestis).
Coxiella sp.	1	2	Coxiella, causative agent of Q Fever both aerosolized and tick-borne. Found in a Male trapped in 2023.
Haemophilus influenzae	1	11	Haemophilus influenzae found in a Female trapped in 2023. This taxon is ubiquitous and may cause a range of nonserious to serious diseases.
Corynebacterium tuberculostearicum	3	156	Lipophilic Gram positive rod inhabiting mucousal membranes.
Legionella sp.	3	132	Potentially pathogenic genus found in aquatic environments

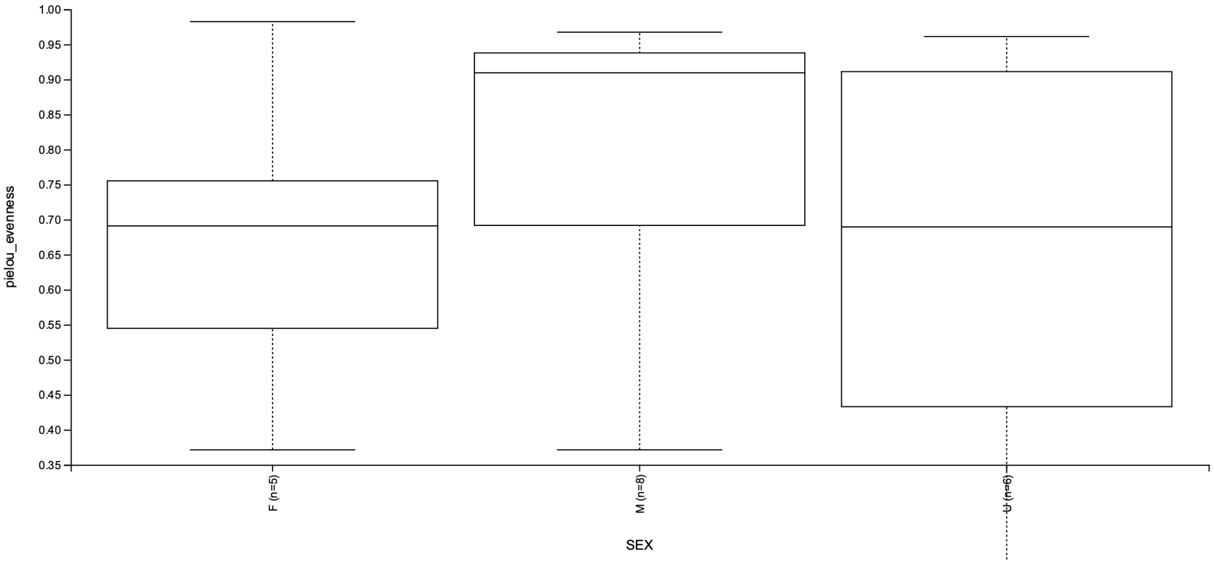


Figure 6. Comparison of Pielou's phylogenetic evenness (by sex of shrike). Evenness does not statistically differ between sexes. Line indicates median with lower and upper quartiles denoted by box, whiskers indicate 1.5 times interquartile range. No significant differences between sex (Kruskal-Wallace test, $H = 1.3579$, df = 2, $P = 0.5072$).

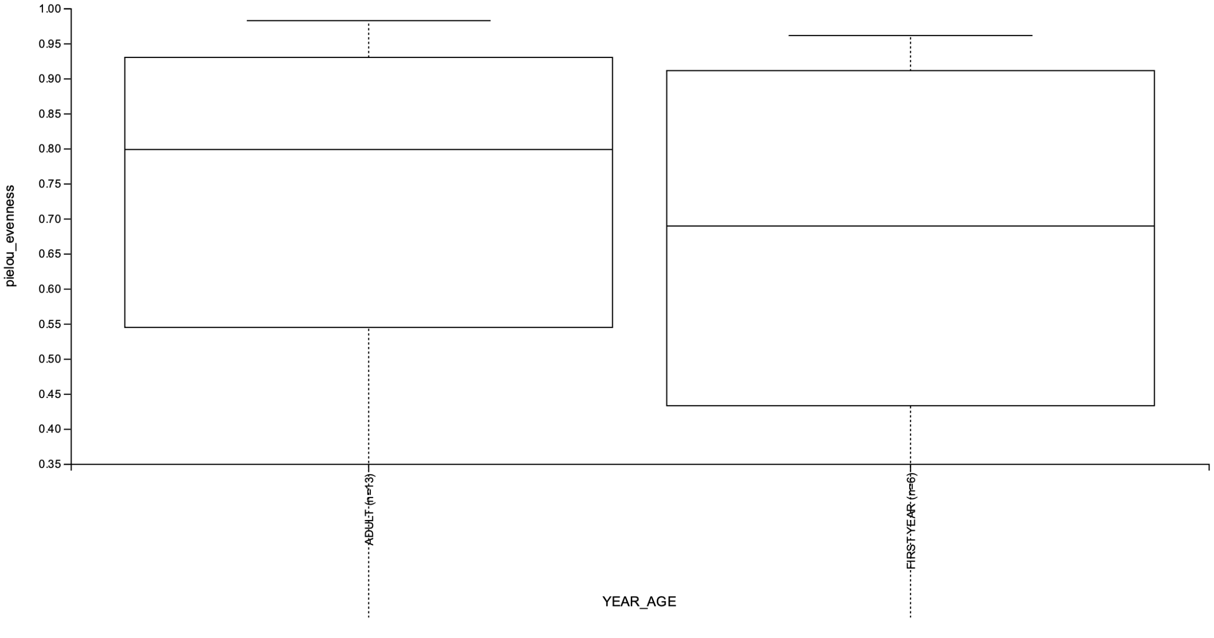


Figure 7. Comparison of Pielou's phylogenetic evenness (by age of shrike). Evenness does not statistically differ between ages. Line indicates median with lower and upper quartiles denoted by box, whiskers indicate 1.5 times interquartile range. No significant differences between age (Kruskal-Wallace test, $H = 0.0449$, df = 1, $P = 0.8322$).

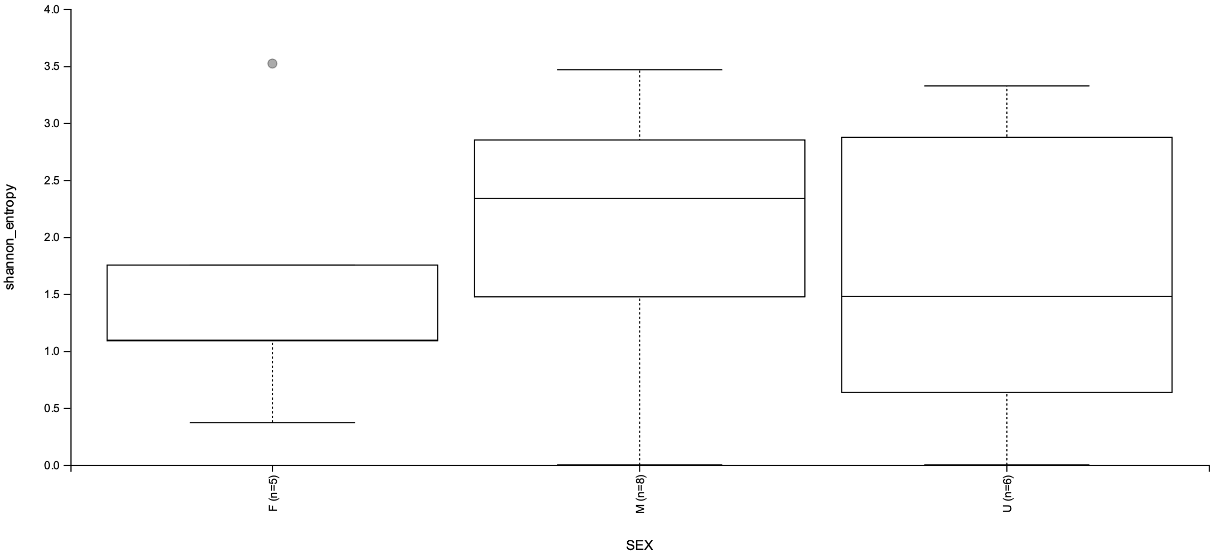


Figure 8. Comparison of alpha phylogenetic diversity (by sex of shrike) as estimated by Shannon Entropy. Alpha diversity does not statistically differ between sexes. Line indicates median with lower and upper quartiles denoted by box, whiskers indicate 1.5 times interquartile range. Dot denotes likely outlier. No significant differences between sex (Kruskal-Wallace test, *H* = 0.6214, df = 2, *P* = 0.7329).

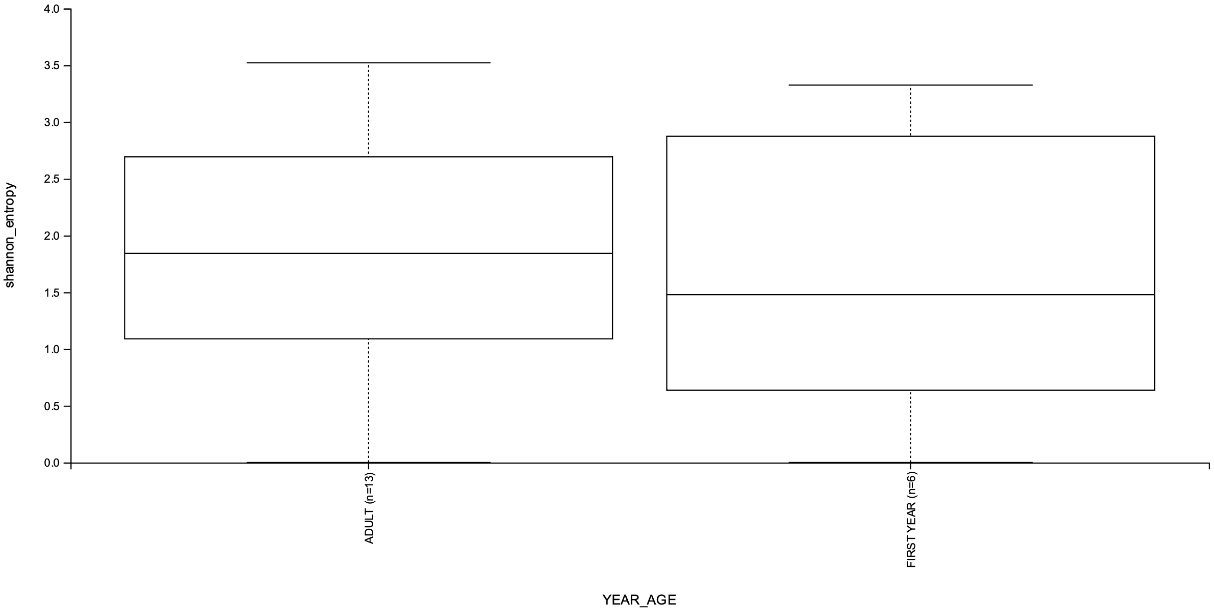


Figure 9. Comparison of alpha phylogenetic diversity (by age of shrike) as estimated by Shannon Entropy. Alpha diversity does not statistically differ between sexes. Line indicates median with lower and upper quartiles denoted by box, whiskers indicate 1.5 times interquartile range. No significant differences between age (Kruskal-Wallace test, *H* = 0.2345, df = 1, *P* = 0.6282).

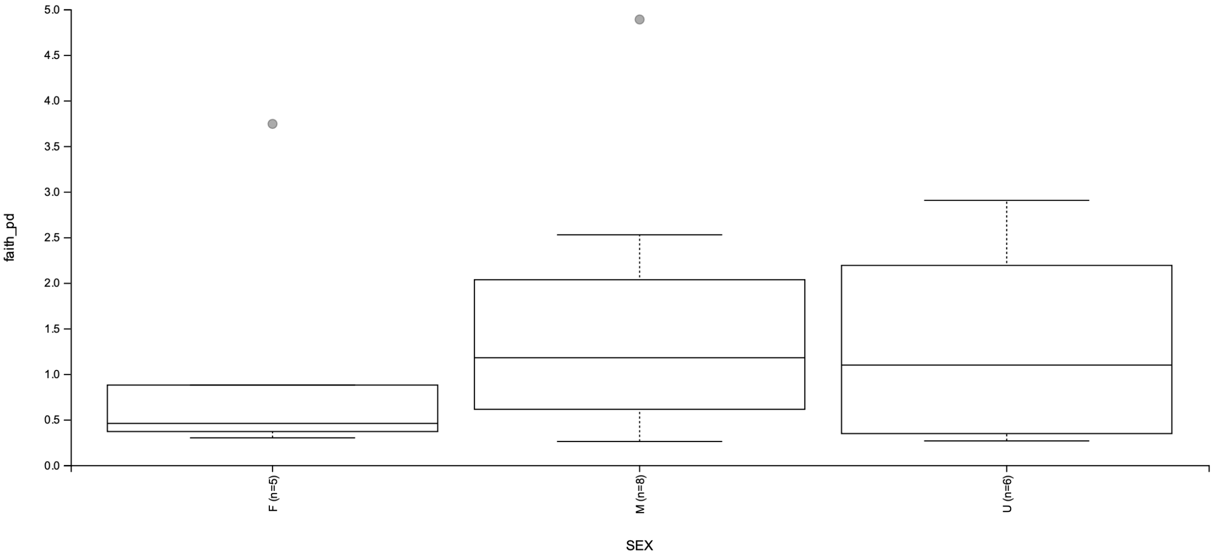


Figure 10. Comparison of alpha phylogenetic diversity (by sex of shrike) as estimated by Faith's PD. Alpha diversity does not statistically differ between sexes. Line indicates median with lower and upper quartiles denoted by box, whiskers indicate 1.5 times interquartile range. Dots denote likely outlier. No significant differences between sex (Kruskal-Wallace test, $H = 0.1766$, df = 2, $P = 0.9155$).

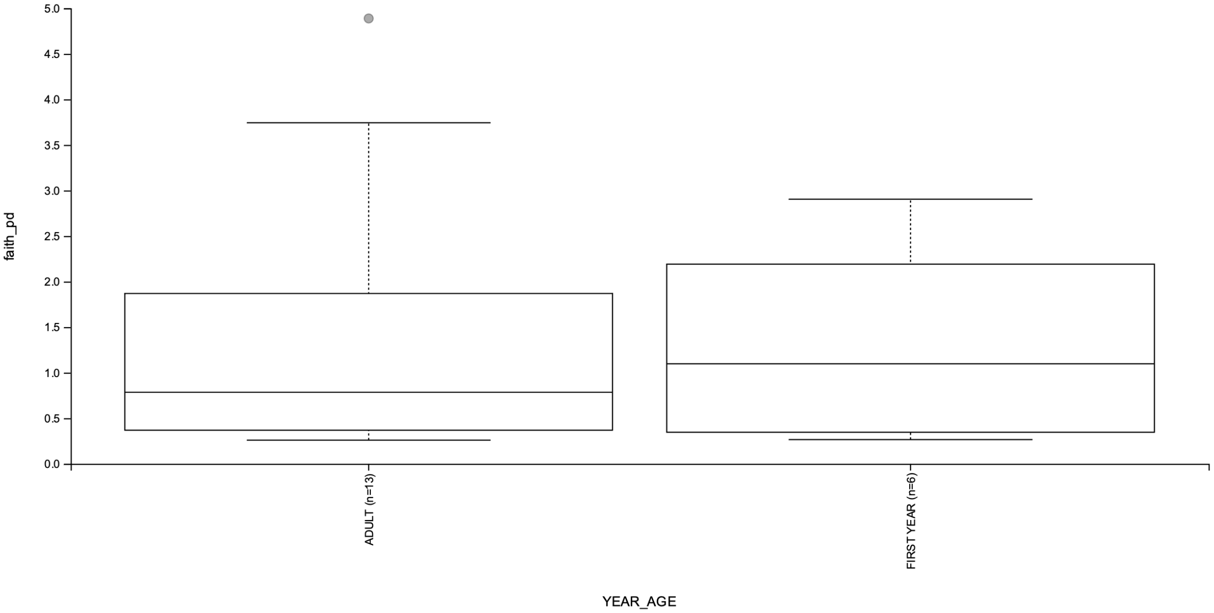


Figure 11. Comparison of alpha phylogenetic diversity (by age of shrike) as estimated by Faith's PD. Alpha diversity does not statistically differ between age. Line indicates median with lower and upper quartiles denoted by box, whiskers indicate 1.5 times interquartile range. Dot denotes likely outlier. No significant differences between age (Kruskal-Wallace test, $H = 0.0308$, df = 1, $P = 0.8608$).

Discussion

Herein, we describe one of the first samplings of Northern Shrike microbiomes. Taken from fecal material, the wintering Northern Shrike microbiome compares well with that of other wild passerines with a heavy preponderance of Proteobacteria, Firmicutes, and Actinobacteriota (88.8%, 9.9%, and 0.9%, respectfully). However, our results notably depart from the common four bacterial phyla in that we identified few bacteria within Phylum Bacteroidetes (0.015%). (Waite and Taylor 2014, Grond et al. 2018). Many taxa were types of bacteria largely associated with soils and aquatic environments likely corresponding with their habitat and dietary associations (Atkinson and Cade 1993). In a pattern similar to that described by Hird et al. (2015) Northern Shrike samples appear to be enriched in Proteobacteria with low Actinobacteriota and Bacteroidetes. We believe that one shrike in particular may have skewed our results enlarging the preponderance of Phylum Proteobacteria specifically due to large numbers of *Pseudomonas* sp. reads. Shrike 1412-82980 contributed over 87% of reads belonging to this phylum with most corresponding to *Pseudomonas* sp. and *Diplorickettsia* sp.. This shrike exhibited no clinical signs of illness but, perhaps along with a number of *Rickettsiella* reads may have been impacted by a high ectoparasite load (Figure 3 and Table 1). This latter genus is generally thought of as a pathogen of arthropods, especially ticks (Bouchon et al. 2011). The high number of reads of this genus, along with the high number of *Pseudomonas* sp. reads makes us wonder if this bird carried ticks (*Ixodes* sp. perhaps) and may have experienced such an opportunistic secondary infection (Abd El-Ghany 2021). It is noteworthy that nestling fecal microbiomes increased in *Rickettsiella* abundance over the nestling period in a study of Gray-Backed Shrikes *Lanius tephronotus* (Hu et al. 2022). Also, in that same study, phyla Proteobacteria and Firmicutes predominated. Do shrikes depart from the usual passerine microbiome?

In removing the aforementioned shrike, Phylum Proteobacteria proportional representation falls to 57.4% while the other phyla correspondingly increased (Firmicutes 39.6%, Actinobacteriota 2.4%). Desulfobacterota decreased to 0.1%. Clearly, this individual, showing a substantially different taxonomic distribution than the other shrikes, was experiencing an unusual gut microbiome. Diet and environment have been shown to strongly influence gut microbiome (Teyssier et al. 2018) so we may not even need to rely upon alimentary disfunction in describing this situation. More study on characterizing individual microbiomes needs done.

We observed no statistically significant differences in patterns of OTU (species) evenness and diversity across Northern Shrikes by sex and age (Figures 6-11). This is not surprising in that we only sequenced 19 birds. However, even with this low sample size, a slight trend was seen in which males exhibited higher evenness and diversity values, albeit not significantly so. We can only imagine that if we were to be able to adequately assign sex to all shrikes in hand (i.e., genetically), we may have more readily observed a pattern. Hence, more study is certainly needed here with the call to couple microbiome data with genetic sexing of shrikes for a more comprehensive approach. For instance, the slightly higher values for males may indicate sex differences in microbiome metabolic function rather than evenness and diversity (see Teyssieret al. 2018). Again, our outlying male shrike may be driving our seemingly observed pattern, which may be especially the case in the interpretation of Shannon Entropy, an apparent high amount of disorder or unpredictability in the male shrikes. On the other hand, Herder et al. (2023) note that alpha diversity of the microbiome varies so substantially across bird species, as well as mean body size and season, that significant differences may be spurious.

In conclusion, we show a relatively diverse assemblage of bacteria contained within the feces of wintering Northern Shrikes. A majority of these taxa are associated with terrestrial and/or aquatic environments in a not-surprising pattern following shrike habitat associations and dietary breadth. As shrikes differ substantially in diet from many other passerines, we urge other shrike researchers to collect fecal samples and characterize the microbiome of shrikes encountered. Even though Kropáčková, et al. (2017) found that host ecology has limited effect on the microbiome, host phylogeny and microbiome were intimately linked. This association points to opportunities to describe the microbiome assemblage across the Laniidae and across geography, biome, and diet.

Acknowledgments

Research reported in this publication was supported by the National Institute of General Medical Sciences of the National Institutes of Health under Award Number P20GM103432. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. Northwest College, Powell, Wyoming USA, provided laboratory space and consumables. Fieldwork was conducted via grants from the Friends of Sax-Zim Bog and the Minnesota Ornithologists' Union, with additional support and equipment provided by Hawk Ridge Bird Observatory. All work was performed under appropriate Federal and State permits.

We thank David Alexander, Hannah Toutonghi, David Valine, and many other volunteers for assistance in the field. Sean Harrington, University of Wyoming INBRE Data Science Core, greatly assisted with data analysis. Joseph Sevigny and Dylan Thomas (Hubbard Center for Genomics, University of New Hampshire) expertly guided us through the QIIME2 pipeline.

References

Abd El-Ghany, W. A. 2021. *Pseudomonas aeruginosa* infection of avian origin: Zoonosis and one health implications. *Veterinary World* 14:2155.

Allali, I., J. W. Arnold, J. Roach, M. B. Cadenas, N. Butz, H. M. Hassan, M. Koci, A. Ballou, M. Mendoza, R. Ali, and M. A. Azcarate-Peril. 2017. A comparison of sequencing platforms and bioinformatics pipelines for compositional analysis of the gut microbiome. *BMC Microbiology* 17:1–16.

Atkinson, E. C. 1993. Winter territories and night roosts of Northern Shrikes in Idaho. *Condor* 95:515–527.

Atkinson, E. C. 1995. Northern Shrikes (*Lanius excubitor*) wintering in North America; a Christmas Bird Count analysis of trends, cycles, and interspecific interactions. *Proceedings of the Western Foundation of Vertebrate Zoology* 6:39–44.

Atkinson, E. C. 1997. Singing for your supper: acoustical luring of avian prey by Northern Shrikes. *Condor* 99:203–206.

Atkinson, E. C., and T. J. Cade. 1993. Winter foraging and diet composition of Northern Shrikes in Idaho. *Condor* 95:528–535.

Brady, R. S., J. D. Paruk, and A. J. Kern. 2009. Sexing adult Northern Shrikes using DNA, morphometrics, and plumage. *Journal of Field Ornithology* 80:198–205.

Bolyen, E., J. R. Rideout, M. R. Dillon, N. A. Bokulich, C. C. Abnet, G. A. Al-Ghalith, H. Alexander, E. J. Alm, M. Arumugam, F. Asnicar, Y. Bai, J. E. Bisanz, K. Bittinger, A. Brejnrod, C. J. Brislawn, C. T. Brown, B. J. Callahan, A. M. Caraballo-Rodríguez, J. Chase, E. K. Cope, R. Da Silva, C. Diener, P. C. Dorrestein, G. M. Douglas, D. M. Durall, C. Duvallet, C. F. Edwardson, M. Ernst, M. Estaki, J. Fouquier, J. M. Gauglitz, S. M. Gibbons, D. L. Gibson, A. Gonzalez, K. Gorlick, J. Guo, B. Hillmann, S. Holmes, H. Holste, C. Huttenhower, G. A. Huttley, S. Janssen, A. K. Jarmusch, L. Jiang, B. D. Kaehler, K. B. Kang, C. R. Keefe, P. Keim, S. T. Kelley, D. Knights, I. Koester, T. Kosciolek, J. Kreps, M. G. I. Langille, J. Lee, R. Ley, Y. X. Liu, E. Loftfield, C. Lozupone, M. Maher, C. Marotz, B. D. Martin, D. McDonald, L. J. McIver, A. V. Melnik, J. L. Metcalf, S. C. Morgan, J. T. Morton, A. T. Naimey, J. A. Navas-Molina, L. F. Nothias, S. B. Orchanian, T. Pearson, S. L. Peoples, D. Petras, M. L. Preuss, E. Pruesse, L. B. Rasmussen, A. Rivers, M. S. Robeson, P. Rosenthal, N. Segata, M. Shaffer, A. Shiffer, R. Sinha, S. J. Song, J. R. Spear, A. D. Swafford, L. R. Thompson, P. J. Torres, P. Trinh, A. Tripathi, P. J. Turnbaugh, S. Ul-Hasan, J. J. J. van der Hooft, F. Vargas, Y. Vázquez-Baeza, E. Vogtmann, M. von Hippel, W. Walters, Y. Wan, M. Wang, J. Warren, K. C. Weber, C. H. D. Williamson, A. D. Willis, Z. Z. Xu, J. R. Zaneveld, Y. Zhang, Q. Zhu, R. Knight, and J. G. Caporaso. 2019. Reproducible, interactive, scalable, and extensible microbiome data science using QIIME 2. *Nature Biotechnology* 37:852–857. https://doi.org/10.1038/s41587-019-0209-9

Bouchon, D., R. Cordaux, and P. Grève. 2011. *Rickettsiella*, intracellular pathogens of arthropods. Pages 127–146 in E. Zchori-Fein and K. Bourtzis, editors. *Manipulative tenants: Bacteria associated with arthropods*. CRC Press, Boca Raton, FL, USA.

Cade, T. J. 1967. Ecological and behavioral aspects of predation by Northern Shrike. *Living Bird* 6:43–86.

Cade, T. J., and T. Swem. 1995. Ecology of Northern Shrikes nesting in arctic Alaska. *Proceedings of the Western Foundation of Vertebrate Zoology* 6(1):204–214.

Craig, S. H. 1997. What goes around–gets caught!! An improved trap for shrikes. *North American Bird Bander* 22:124–125.

Estaki, M., L. Jiang, N. A. Bokulich, D. McDonald, A. González, T. Kosciolek, C. Martino, Q. Zhu, A. Birmingham, Y. Vázquez-Baeza, and M. R. Dillon. 2020. QIIME 2 enables comprehensive end-to-end analysis of diverse microbiome data and comparative studies with publicly available data. *Current Protocols in Bioinformatics* 70(1) p.e100.

Faith, D. P. 1992. Conservation evaluation and phylogenetic diversity. *Biological Conservation* 61:1–10.

Grond, K., B. K. Sandercock, A. Jumpponen, and L. H. Zeglin. 2018. The avian gut microbiota: community, physiology, and function in wild birds. *Journal of Avian Biology* 49(11)

Herder, E. A., H. R. Skeen, H. L. Lutz, and S. M. Hird. 2023. Body size poorly predicts host-associated microbial diversity in wild birds. Microbiology Spectrum 11 pp.e03749-22.

Hird, S. M., C. Sánchez, B. C. Carstens, and R. T. Brumfield. 2015. Comparative gut microbiota of 59 neotropical bird species. *Frontiers in Microbiology* 6:1403.

Hu, J., J. Zeng, Y. Shi, and S. Song. 2022. Are microbes and metabolites influencing the parental consumption of nestlings' feces in gray-backed shrikes? *Current Zoology* 68(6):667–678.

Kropáčková, L., M. Těšický, T. Albrecht, J. Kubovčiak, D. Čížková, O. Tomášek, J. F. Martin, L. Bobek, T. Králová, P. Procházka, and J. Kreisinger. 2017. Codiversification of gastrointestinal microbiota and phylogeny in passerines is not explained by ecological divergence. *Molecular Ecology* 26:5292–5304.

Negruțiu, V., M. Niculae, E. Páll, C. D. Șandru, F. Brudașcă, A. Vasiu, S. Popescu, and M. Spînu. 2017. Is the antibiotic resistance of the microbiome in birds from the Danube Delta influenced by migratory and feeding behaviors? Available from: https://www.cabidigitallibrary.org/doi/full/10.5555/20173356066

Paruk, J. D., S. J. Cooper, A. O. Mangan, R. S. Brady, and L. Tucker. 2015. Resting metabolic rates of adult Northern Shrikes (*Lanius excubitor*) wintering in Northern Wisconsin. *Wilson Journal of Ornithology* 127(3):510–514.

Paruk, J. D., T. J. Cade, E. C. Atkinson, P. Pyle, and M. A. Patten. 2020. Northern Shrike (*Lanius borealis*), version 1.0. In S. M. Billerman (Ed.), Birds of the World. Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.norshr4.01.

Pielou, E. 1966. The measurement of diversity in different types of biological collections. Journal of Theoretical Biology 13:131–144.

Rimmer, C. C., and C. H. Darmstadt. 1996. Non-breeding site fidelity in Northern Shrikes. Journal of Field Ornithology 67:360–366.

Rosenberg, K. V., J. A. Kennedy, R. Dettmers, R. P. Ford, D. Reynolds, J. D. Alexander, C. J. Beardmore, P. J. Blancher, R. E. Bogart, G. S. Butcher, A. F. Camfield, A. Couturier, D. W. Demarest, W. E. Easton, J. J. Giocomo, R. H. Keller, A. E. Mini, A. O. Panjabi, D. N. Pashley, T. D. Rich, J. M. Ruth, H. Stabins, J. Stanton, and T. Will. 2016. Partners in Flight Landbird Conservation Plan: 2016 Revision for Canada and

Continental United States. Partners in Flight Science Committee. https://www.partnersinflight.org/resources/the-plan/.

Shannon, C. E., and W. Weaver. 1949. The mathematical theory of communication. University of Illinois Press, Champaign, Illinois, USA.

Teyssier, A., L. O. Rouffaer, N. S. Hudin, D. Strubbe, E. Matthysen, L. Lens, and J. White. 2018. Inside the guts of the city: urban-induced alterations of the gut microbiota in a wild passerine. Science of the Total Environment 612:1276–1286.

Yosef, R. 1994. Conservation commentary: An evaluation of the global decline in the True Shrikes (Family Laniidae). Auk 111:228–233.

Yosef, R., and F. Lohrer. (Eds). 1995. Shrikes (Laniidae) of the World: Biology and Conservation. Proceedings of the Western Foundation of Vertebrate Zoology 6.

Yosef, R., and F. Lohrer. 1998. Shrikes of the world - II: Conservation implementation. Proceedings of the Second International Shrike Symposium. 17–23 March 1996. IBCE Technical Publication 7.

Waite, D. W., and M. W. Taylor. 2014. Characterizing the avian gut microbiota: membership, driving influences, and potential function. Frontiers in Microbiology 5:223.

European Journal of Ecology, 2024, 43-68

RED-BACKED SHRIKES *LANIUS COLLURIO* LINNAEUS, 1758 IN SOUTHERN AFRICA

Ursula Bryson[1] and Dane M. Paijmans[2]

[1] *Research Associate at the FitzPatrick Institute of African Ornithology, University of Cape Town, South Africa. ursula@thomas-bryson.de, ORCID 0009-0003-6314-0959*
[2] *22 Elizabeth Street, Hobart, Tasmania, 7000, Australia, ORCID* 0000-0001-5938-2486

Abstract.

Published data on migratory birds in their non-breeding grounds are scarce. After ringing and gathering biometric and moult data for more than twenty years in the countries of the southern part of Africa, we are now summarizing our findings. Here, our focus is on the plumage of first-year and adult Red-backed Shrikes Lanius collurio developing during their stay as an aide for the age distinction in the field. We present moult data of both age groups and show moult progression and plumage variation by photographic evidence.

Key words: *shrike; non-breeding grounds; moult; plumage variation; age development; Africa*

Figure 1. Arid savannah of the pre-Namib: one non-breeding habitat of the Red-backed Shrike *L. collurio* in western Namibia. 13 January 2005.

Introduction

After ringing a wide variety of species for more than twenty years in southern African countries, my co-author Dane Paijmans and I are now publishing our results with a focus on species and subspecies mainly from Namibia (Fig. 1) that are lacking data from the field (Paijmans & Bryson 2023). Our "bird bible" of southern Africa, the Roberts (Hockey et al. 2005), is being revised 15 years after the last, the 7th edition, and in this process, the content is being merged with the Handbook of the Birds of the World in the Macaulay Library.

We have published data on moult development and biometric measurements and observations about migratory and resident shrike species: Southern Fiscal *Lanius collaris* Linnaeus, 1766 (Bryson & Paijmans 2021), White-crowned Shrike *Eurocephalus anguitimens* A. Smith, 1836 (2022) and Red-backed Shike *L. collurio* (2023b) as well as about other species: Tractrac Chat *Emarginata tractrac* (Bryson et al. 2023) and Mountain Wheatear *Myrmecocichla monticola* Vieillot, 1818 (Bryson & Paijmans 2023a). Right now we are working on our paper on the Lesser Grey Shrike *Lanius minor* Gmelin, 1788, the

Karoo Chat *Emarginata schlegelii* Wahlberg, 1855 and the Namaqua Sandgrouse *Pterocles namaqua* Gmelin, 1789.

This paper presents some of our findings on the Red-backed Shrike *Lanius colllurio*. We focused on features that help to identify age groups when ringing the birds.

Distribution and Sites

The non-breeding area of the Red-backed Shrike encompasses about the southern and eastern third of the African continent (Fig. 2). We primarily work in Namibia, in a dry habitat, either in the western arid savannah of the pre-Namib (Fig. 3A, B) or towards the east in the often encroached savannah closer to the Botswana border (Fig. 4).

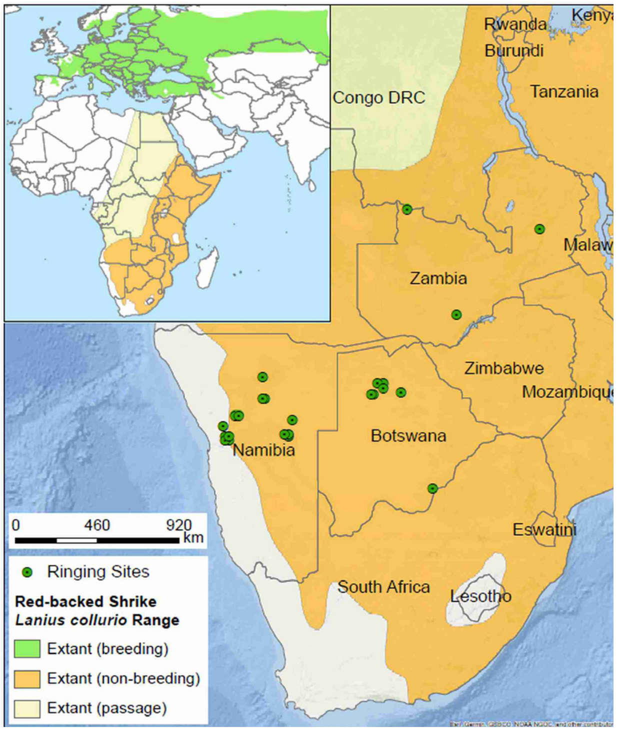


Figure 2. The Red-backed Shrike distribution map was downloaded from www.iucnredlist.org on 18 May 2019. Green dots designate sites where data were gathered in the current study.

The area is dry most of the year; the sustainable average rainfall is 45 mm/year. However, the landscape's appearance rapidly changes with rainfall, and more individuals and more species arrive overnight or within a few days.

We catch with mist nets or spring traps with mealworms as bait, especially along fences (Fig. 4). This proved to be a good catching strategy for shrikes, pipits, larks, chats, roller, starlings, and hornbills. We have ringed almost 2000 shrikes and bush-shrikes of about 20 species, 350 are Red-backed Shrikes and the same number of Lesser Grey Shrikes.

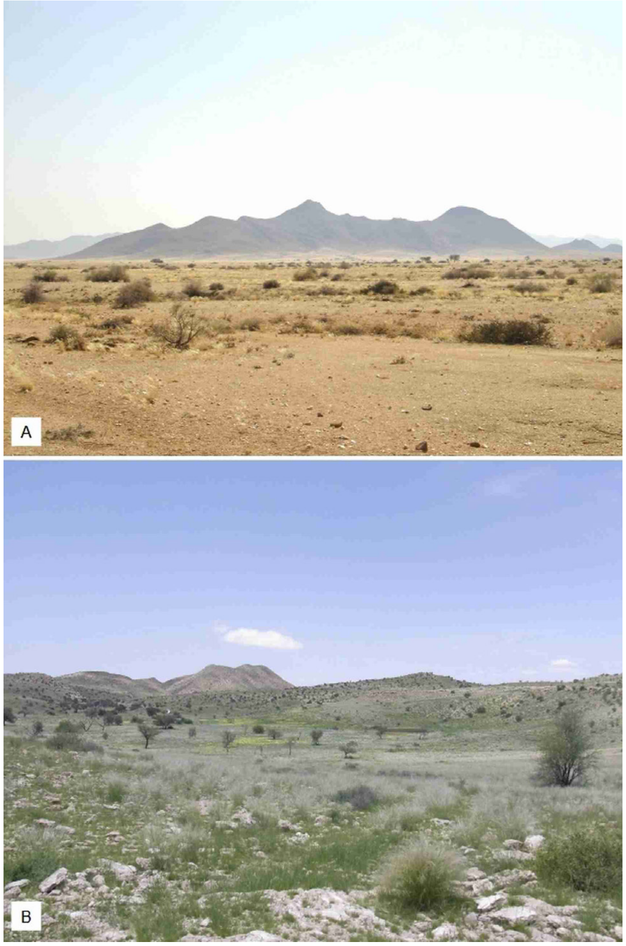


Figure 3. Our main catching area in the pre-Namib, 120 km from the coast. The bushes are used as perches by the shrikes and other species. (A) During the dry season, 15 June 2005.
(B) After two good rainfalls, the area turns green, and flowers bloom, February 2011.

Figure 4. Traps on a farm road in eastern Namibia.18 January 2023.

This paper contains our findings and observations of the Red-backed Shrike. For the biometric data and more details of our research, see Bryson & Paijmans (2023b). For further studies see Heinroth & Heinroth (1924), Traylor (1965), Clancey (1973), Skead (1973), Panow (1983), Bruderer & Bruderer (1994), Herremans (2005), Bruderer (2007), Dowsett (2009), Blasco-Zumeta & Heinze (2019) and SABAP (2022)

Specifically for moult see Stresemann (1963), Snow (1965), Kasparek (1981), Ginn & Melville (1983), Demongin (2016) and Jenni & Winkler (2020a, b).

RESULTS FOR RED-BACKED SHRIKES

Beyond the biometric data, our monitoring was directed to the moult development throughout the months. We observed a considerable variation of phenotypes, especially in females and young birds.

Moult development of primary feathers, tail, head, and body in Red-backed Shrikes

The development of the primary moult throughout the months for first-year and adult Red-backed Shrikes and the percentage of recorded moult on the head, tail, and body were recorded (Table 1, 2).

Table 1. Extent of primary feather moult (P1 to P10) of **first-year** Red-backed Shrikes in the non-breeding grounds in Namibia, Botswana, and Zambia. The average moult scores between 0 and 1 result from a few individuals with two sprouting primaries (moult score 2). Values are the average moult scores of each primary for the n birds per month sampled. The color gradient is shown at the side. The tail (t), head (h), and body (b) are expressed as a percentage of birds assessed showing signs of active moult. No data were collected during the months marked in grey.

Month	n	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	t	h	b
Jul	0													
Aug	0													
Sep	0													
Oct	0													
Nov	6	0	0	0	0	0	0	0	0	0	0	0%	0%	0%
Dec	44	1	1	0	0	0	0	0	0	0	0	10%	0%	3%
Jan	79	4	4	3	2	1	1	0	0	0	0	67%	16%	29%
Feb	32	4	4	4	4	4	3	2	0	0	0	95%	37%	50%
Mar	44	4	4	4	4	4	4	4	4	3	2	83%	91%	82%
Apr	0													
May	0													
Jun	0													

Moult Score
0
1
2
3
4
5

Table 2. Extent of primary feather moult (P1 to P10) of **adult** Red-backed Shrikes.

Month	n	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	t	h	b
Jul	0													
Aug	0													
Sep	0													
Oct	0													
Nov	11	0	0	0	0	0	0	0	0	0	0	33%	0%	0%
Dec	27	2	1	1	0	0	0	0	0	0	0	12%	0%	12%
Jan	30	4	4	4	4	3	2	1	0	0	0	75%	25%	56%
Feb	16	5	5	4	5	4	4	4	3	1	0	100%	40%	40%
Mar	23	3	3	3	3	3	3	3	3	3	3	70%	100%	100%
Apr	1	5	5	5	5	5	5	5	5	5	5			
May	0													
Jun	0													

Moult Score
0
1
2
3
4
5

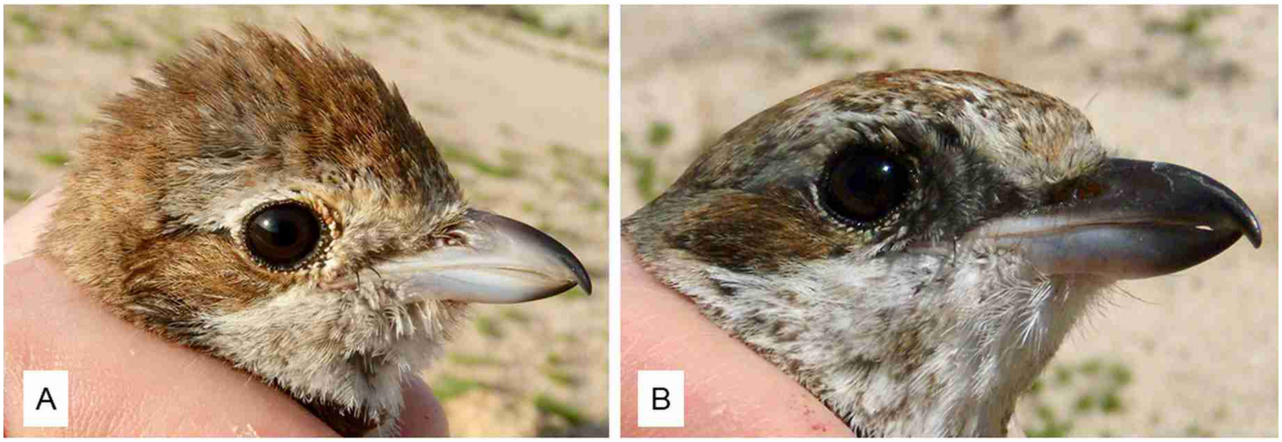


Figure 5. Earliest possible distinction of sexes of first-year Red-backed Shrikes by plumage features on the head and the coloration of the bill: (A) Female with rufous ear coverts and crown, (B) male with first black feathers on ear coverts and mask, and first grey ones on the forehead. 9 January 2011.

First-year Red-backed Shrikes start their primary moult later than adults. Both age groups finish the complete moult before departure in April.

Distinction of sexes in first-year birds

The distinction of sexes is generally possible by February and usually concerns observations in the field. In our sample with the birds in the hand, the features diverged with progressing moult from the end of December and early January onwards (Fig. 5).

DEVELOPMENT OF PLUMAGE IN THE NON-BREEDING GROUNDS

First-year and adult Red-backed Shrikes undergo a complete moult in the non-breeding grounds. Here we depict the process through the months. We can give only examples of moult progress, since it is very variable.

Development of plumage in females from November to March

Red-backed Shrikes arrived in small numbers in our research area in mid-November (see Tables 1 and 2).

First-year and adult females in November

While first-year birds mainly display only a few body feathers in moult (Fig. 6), not all of them we recorded for the summaries. The primary and tertial moult show first (Fig. 6, 7).

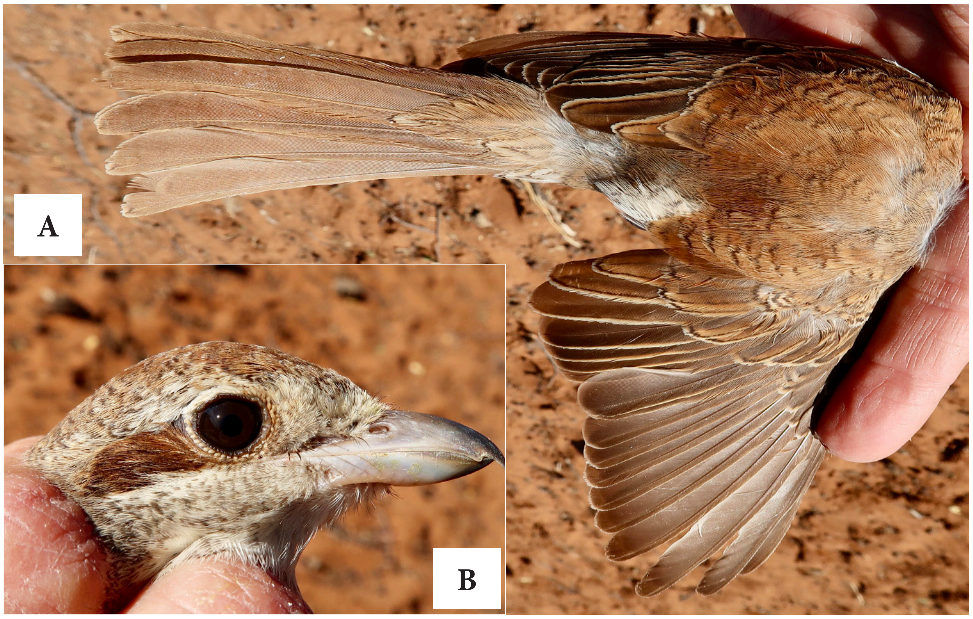


Figure 6. First-year female, on arrival in the non-breeding grounds (A) with hardly worn wing and tail. (B) The sex was determined by the coloration of the ear-coverts and the crown. 17 November 2016.

Figure 7. Adult female with worn tips and first growing primaries. 29 November 2017.

First-year and adult females in December

From December, the two age groups of old and freshly moulted feathers can be distinguished on the mantle, head, and rump, as well as on some first coverts and scapulars (Fig. 8, 9A, B).

Figure 8. First-year female with fresh feathers on the mantle, rump, head, and lesser coverts which betray the sex already at that date. The crown and head lacks any grey and there are no signs of black mask, both signs of males. 20 December 2021.

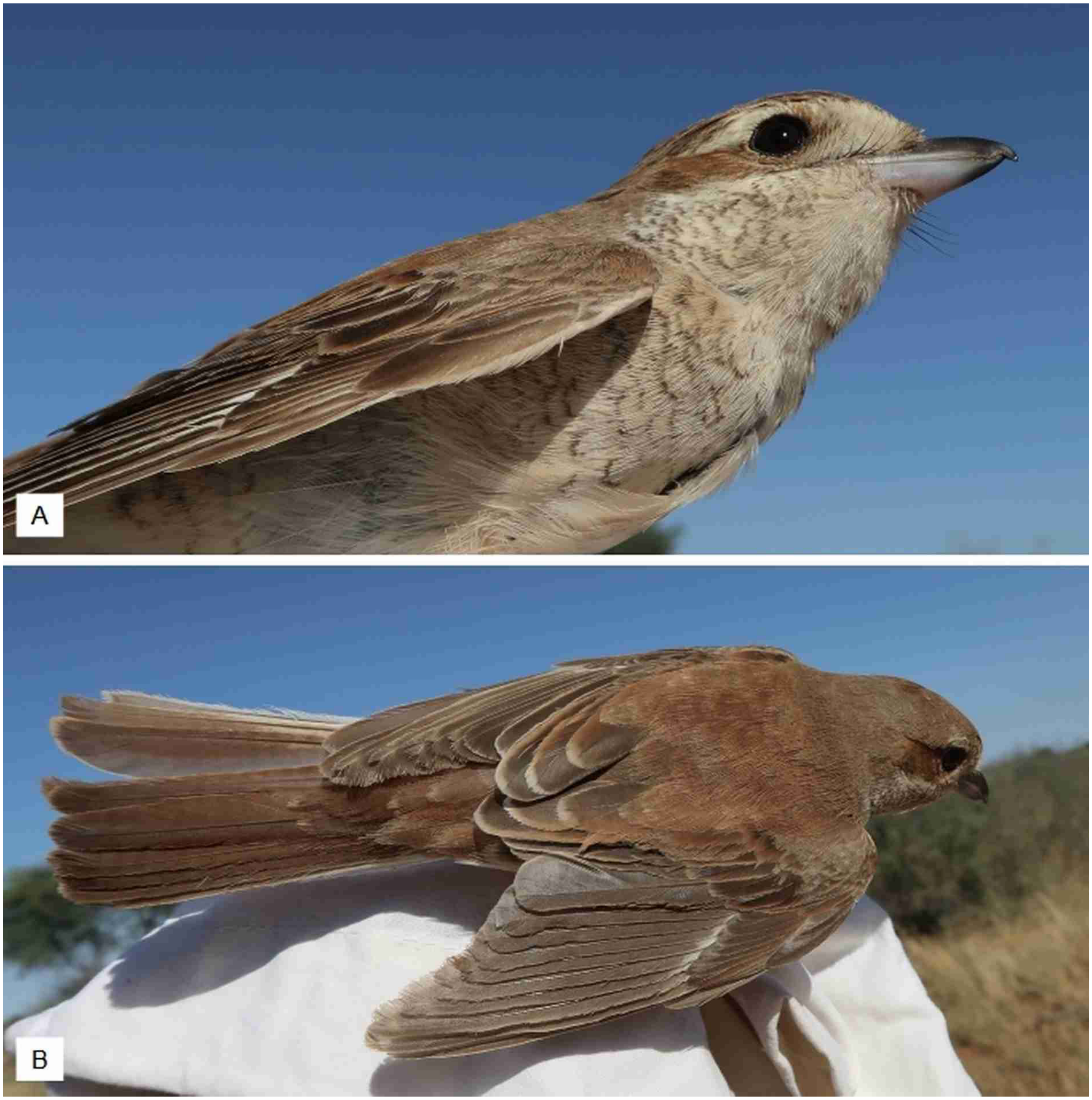


Figure 9. Adult female from below (A) and above (B) with fresh freshly moulted feathers on the mantle, rump, and lesser and median coverts. 9 December 2022.

First-year and adult females in January

In January, the contrast between the two age groups of feathers becomes noticeable (Fig. 10, 11). The feather quality and density in the young birds contrasts with that of the adults.

Rarely could we record a very young individual in January who has not even begun their post-juvenile moult (Fig. 12).

Figure 10. First-year female moulting wing, tail, and body. 23 January 2022.

Figure 11. An adult female with markings of a so-called „juvenile-like“ female on some feather-tips of the rump, mantle and coverts. The adult age was determined by the abraded primaries, the contrasting mantle and greyish neck and the rich coloration of ear-coverts and tail. Furthermore, this individual shows male features, as there is the black coloration above the bill and a central black tail feather sprouting (not visible on this picture). Moult is visible on the mantle, medium coverts, and primaries with corresponding coverts. 7 January 2023.

Figure 12. First-year female, still with white dots, and fringes at the tips, signs of juvenile plumage. 8 January 2023.

First-year and adult females in February

The moult progress continues to be variable. Some birds are still in the moult of primaries, secondaries, tertials (Fig. 13), and tails (Fig. 14A, B), while others have already completed their wing and tail moult (Fig. 15A, B).

Figure 13. First-year female with primary, secondary, and tertial moult. 28 February 2016.

Figure 14. First-year female (A) with wing moult almost completed and tail still growing. 19 February 2015; (B) with wing moult in progress and tail still growing. 28 February 2016.

Figure 15. Adult female with early completed wing (A) and tail (B) moult. 25 February 2022.

First-year and adult females in March

During March, the moult is almost complete (Fig. 16). Age differences can be observed by the quality of the plumage and subtle differences in the markings (Fig. 17A, B).

Figure 16. Adult female in fresh plumage. 18 March 2023.

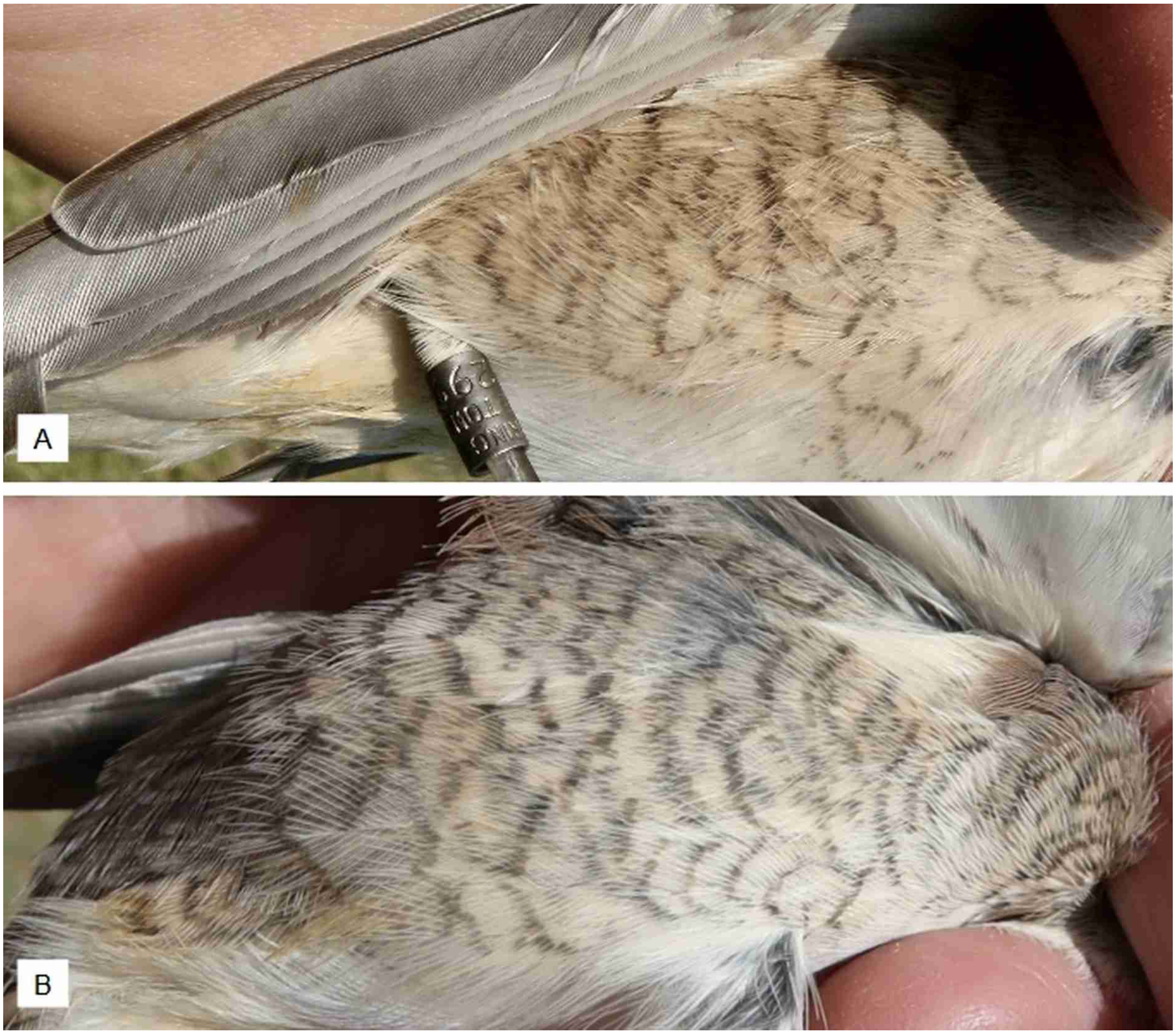


Figure 17. Underparts in March of (A) first-year (of life) and (B) adult female. 12 March 2011 and 24 March 2022, respectively.

Development of plumage in males from November to March

First-year and adult males in November and December

Some first-year males show the first black feathers on the head by the end of November (Fig. 18). In December, with progressing moult, all males in our area were recognizable as such (Fig. 19). The distinction between the age groups is apparent. Adult males show moult on the wing, tail, and mantle (Fig. 20).

Figure 18. First-year with black feathers between bill and eye. The gape flange is still yellow. 29 November 2023.

Figure 19. First-year male with first signs of the black mask and grey head. 5 December 2007.

Figure 20. Adult male moulting wing, coverts, body, and tail. 17 December 2020.

First-year and adult males in January

The differences between the two age groups are still evident in January. The contrast of head and upperparts of first-year males (Fig. 21A) is blatant when compared with adults (Fig. 21B).

First-year and adult males in February

With migration time approaching, moult reaches completion. The plumage of first-year males is converging to that of adults. The age difference is still evident by brown feathers on the head, not yet fully expressed mask and markings on the underparts in the young (Fig. 22A) compared to plain wing head and underparts in adults (Fig. 22B).

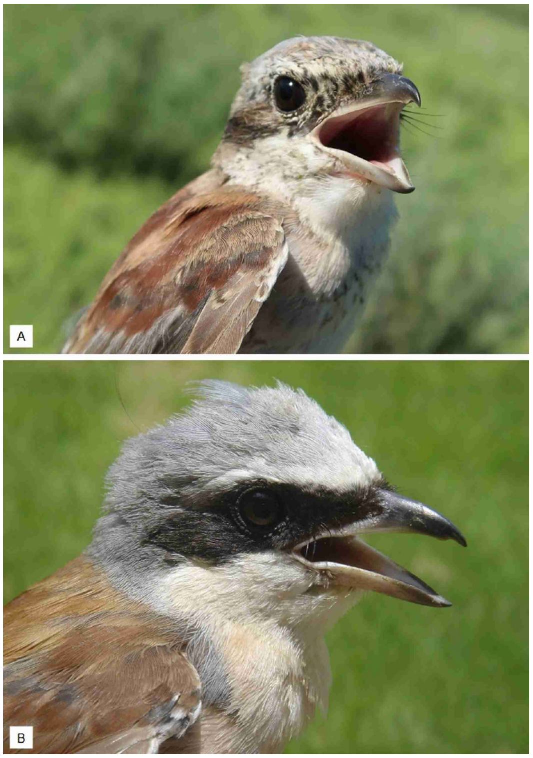


Figure 21. (A) First-year male with his mask and mantle moulting into the darker, more saturated-colored adult plumage. 24 January 2020. (B) Adult male with plain grey head, black mask, and brown wings during his moult. 16 January 2006.

Figure 22. (A) First-year male finishing his primary moult (P10 still old). The light brown feathers on the head will be replaced, and the mask be completed. The underparts still show markings. 25 February 2022. (B) Adult male with plain wing, head, and underparts. 1 February 2020.

First-year and adult males in March

At this stage, moult is almost complete in both age groups (Fig. 23). In March, males in their first year of life can still be distinguished from adults by minute signs like a yellowish gape flange (Fig. 24A) or residual feathers from the (post-)juvenile plumage (Fig. 24B,C).

Color variations of the Red-backed Shrike

An extensive color variation is documented for this species. Possibly, individuals of the whole breeding range from Spain into Siberia spend the non-breeding season in the southern part of Africa, bringing birds of different provenience and formerly discussed subspecies to our research area (Clancey 1973; Cramp & Perrins 1993; del

Figure 23. This first-year male has almost the whole plumage replaced. Some brown feathers on the head, old feathers on the neck, and a growing tail are still visible. 4 March 2019.

Figure 24. The age of some males at the end of their first year of life can be determined by (A) a yellowish gape flange or residual feathers from the (post-)juvenile plumage on (B) the mask or (C) the underparts. (A)18 March 2022, (B) and (C) 25 March 2019.

Hoyo & Collar 2016; Pârâu et al. 2019, 2022; Yosef 2008; Yosef & International Shrike Working Group 2019). Beyond that, vast individual variation has been observed, even with different color expressions already of young in one nest (Stauber in litt. in Bub 1981, p. 113).

Also documented are numerous introgressions through hybridization with Isabelline Shrike (*L. isabellinus* Hemprich & Ehrenberg, 1833), Brown Shrike (*L. cristatus* Linnaeus, 1758), or Turkestan Shrike (*L. phoenicuroides* Schalow, 1875) in the breeding grounds. See Lefranc & Worfolk (2022) and Bryson & Paijmans (2023b) for more details.

Color variations in females

We observed various plumage colorations, especially in females (Fig. 25).

Figure 25. The enormous variation of adult female Red-backed Shrikes ringed in southern Africa, which presumably indicates provenience over a wide range. Observe the diversity of markings and coloration on top of the head, the throat, ear coverts, and the supercilium. (A) Botswana, 28 January 2015; (B) Farm Sphinxblick, Erongo region, 6 January 2011; (C) near Witvlei, 30 March 2015; (D) Botswana, 1 December 2007; (E) near Witvlei, 28 March 2014; (F) Waterberg, Namibia, 15 January 2006.

Color variation in males

Color variation of the upperparts

Beyond a diversity of shades on the upperparts, there are two types of transition from the grey of the neck to the mantle. Some individuals display a clear boundary between the two areas (Fig. 26A); in others, it is a gradient transition (Fig. 26B).

Color variations of the underparts

On the underparts, we also found a broad diversity of shades between grey and pink on the chest (Fig. 27) and most expressed on the flanks (Fig. 28, 29).

Figure 26. Adult males. (A)The mantle is rufous and the wings are brownish. The grey of the head and neck ends in a distinct line. Lake Ngami, Botswana, 10 December 2005. (B) The mantle is grey and red-brown, and the wings are blackish. The grey of the head and neck disperses downwards into the mantle. Witvlei, Namibia, 4 March 2019.

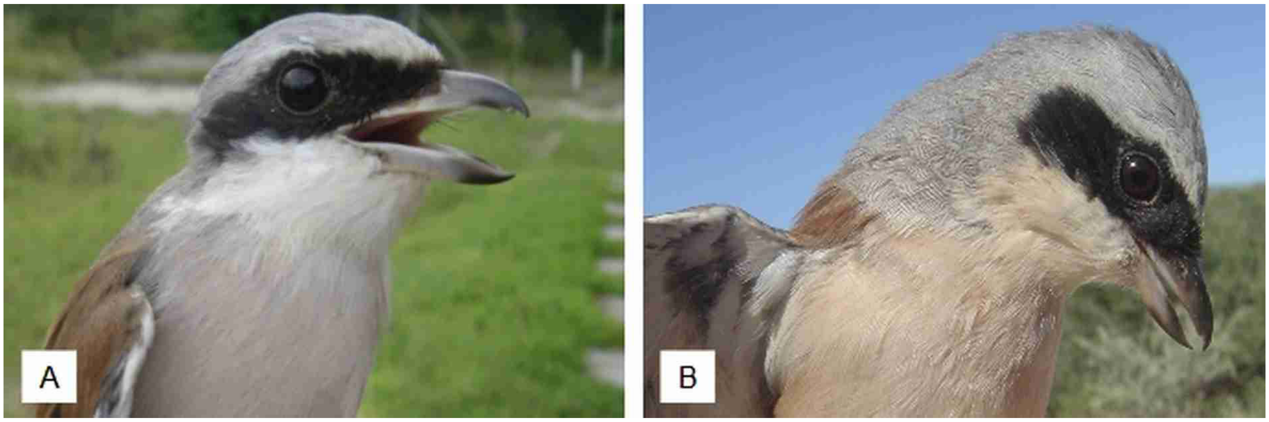


Figure 27. Adult males with (A) cold grey and (B) warm pinkish chest. 21 February 2006 and 2 February 2008, respectively.

Figure 28. The male flanks show a coloration from (A) cold grey with pale pink to (B) light salmon. 20 March 2022 and 16 January 2023, respectively.

Some males show exceptionally rufous or dark flanks, without extraordinary upperparts, such that an introgression by other species is up for discussion (compare Lefranc & Worfolk 2022, p. 219).

Change of coloration of the bill during the non-breeding season

The coloration of the bill provides information about age, sex, and breeding status. It differs between females and males during the breeding and non-breeding season.

Figure 29. Males with extraordinarily (A) rufous and (B) dark flanks. 20 March 2022 and 27 December 2022, respectively.

In July/August, the bills of adults become pale, beginning at the base, and only after the complete moult in the non-breeding area it turns entirely black again, starting from the tip (Harris & Franklin 2000; Jenni & Winkler 2012). The color change is more evident in males (Fig. 30), while the bill of the female "never becomes as dark black as in males" (Kramer 1950, pp. 21-22). Also, during the non-breeding season, the bill of the adult never turns as pale as in young birds (ibid.).

Adult males in the non-breeding grounds show pale bills with black on the upper mandible and the tip of the lower mandible and acquire the black bill of a breeding male shortly before or during migration.

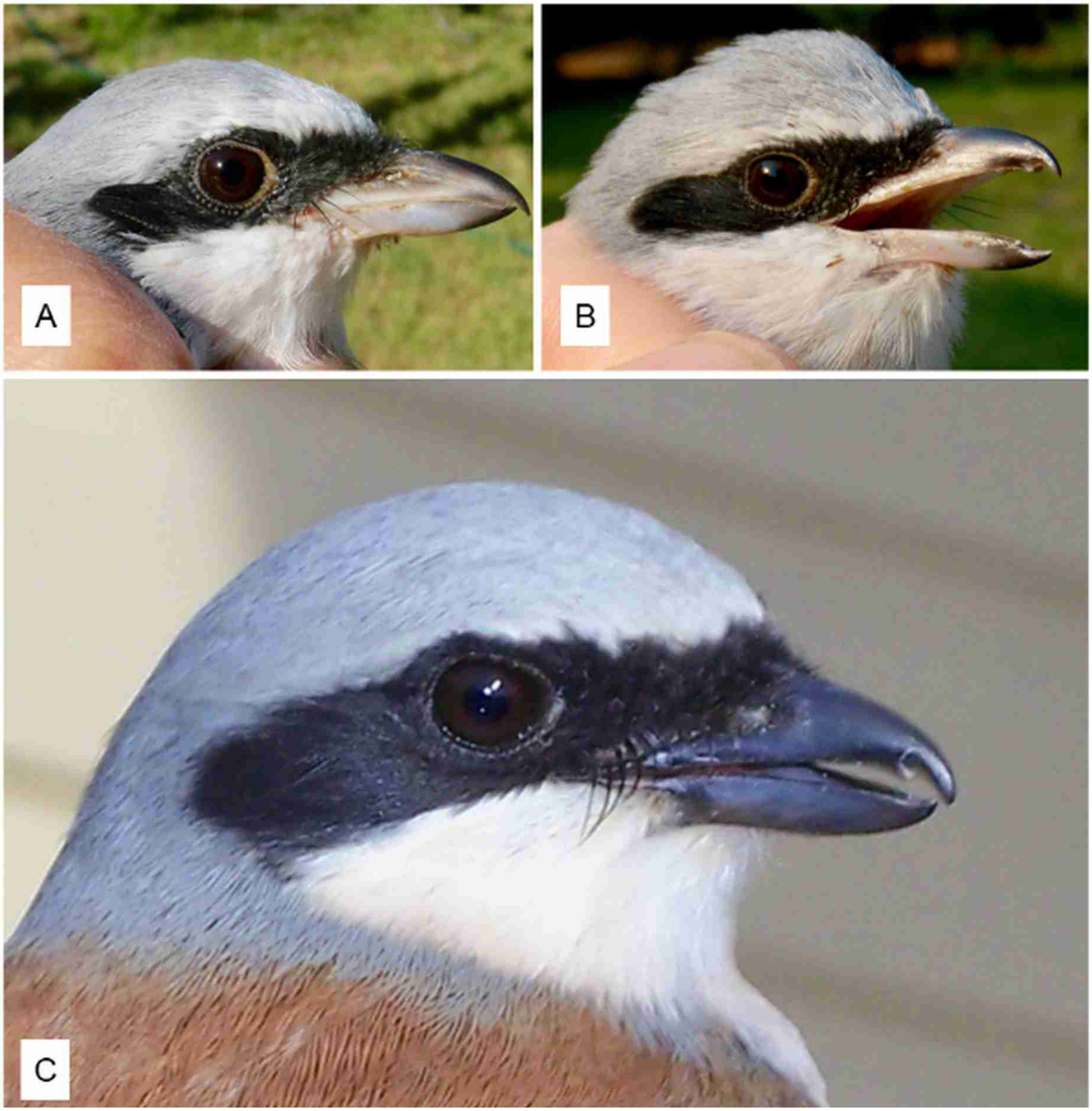


Figure 30. Bill coloration of adult males. The bill is bluish or pinkish pale in the non-breeding grounds, with black on the upper mandible and the tip. (A) 9 March 2011, (B) 12 March 2011. (C) shows a male after arrival in Europe with an entirely black bill. Ventotene Island, Italy, 15 May 2012.

Features of the opposite sex

We recorded a small percentage of the birds processed with features of the opposite sex, well described in the literature. (Bub1981, p.111; Shirihai & Svensson 2018, p. 186; Lefranc & Worfolk 2022, p. 217; Bryson and Paijmans 2023).

Females with male features

A small proportion of the females in our sample have shown male features. Crown, nape, rump, and tail coverts are grey to varying degrees. The tail is plain, and the underparts show the typical female vermiculation (Fig. 31).

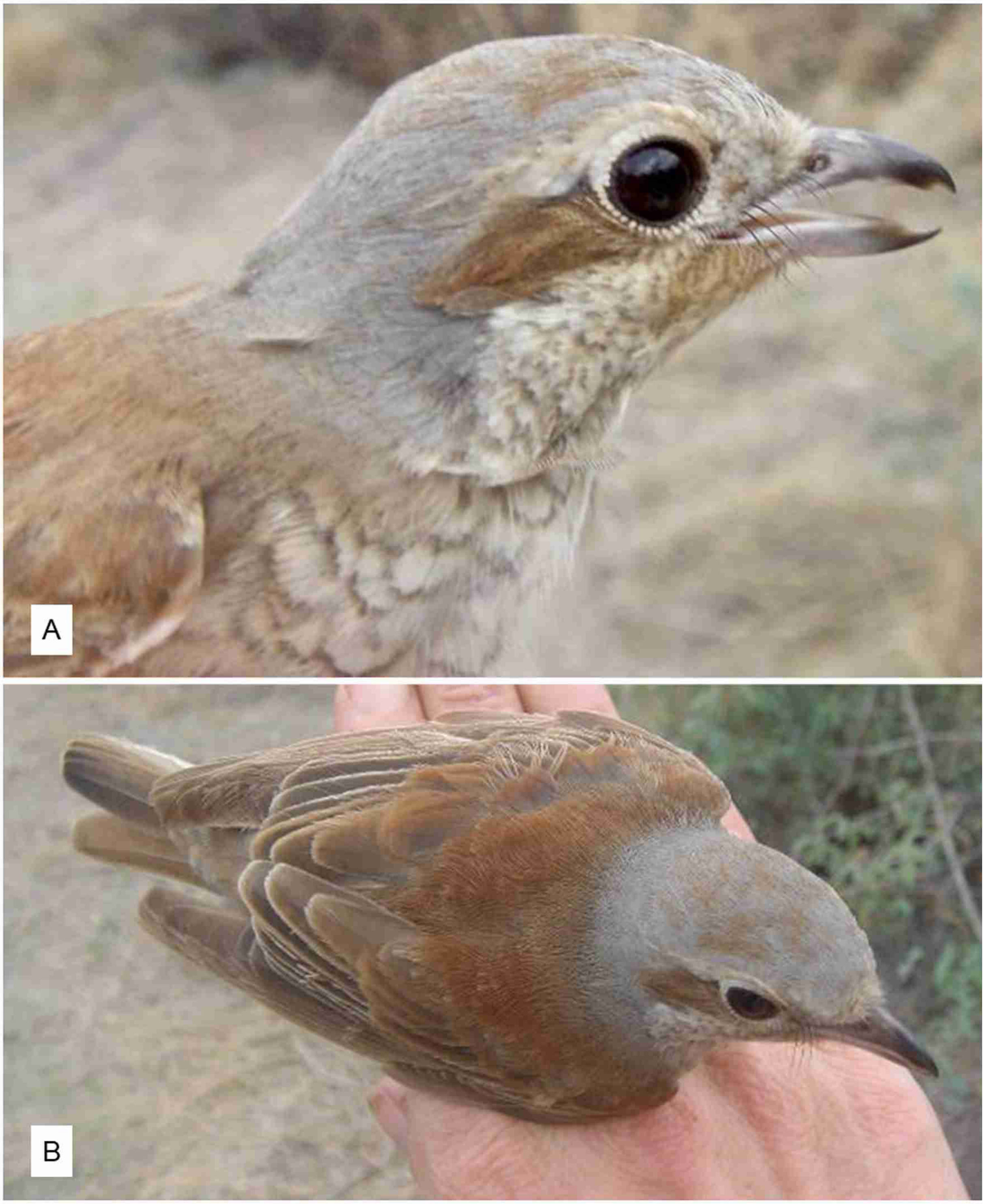


Figure 31. Adult female with unmarked male-like grey nape and crown and dark mantle, but female-colored, uniformly brown tail and ear coverts and typical female vermiculation of the underparts. 1 December 2007.

Adult male with female features

Rarely have we found males with female features where the mask is not fully developed, and the crown of the head and the ear coverts are tinged brown. The tail, though, points out towards a male (Fig. 32).

8. White primary patch (Spiegel)

In our sample, an aggregation of possibly highly diverse origins, several individuals (at least 15% of 164 males) showed a primary patch of varying size. With one exception (Fig. 33), we found primary patches only in males (Fig. 34). The patch has been described in varying forms

Figure 32. Adult male with female-like features: Upperparts with a typical adult male black and white tail pattern, but mostly brown ear coverts and brown top of the head. The mask is not entirely black, while the rump is slate-grey. 26 January 2007.

Figure 33. Adult females with white primary patches are rare. 9 December 2022.

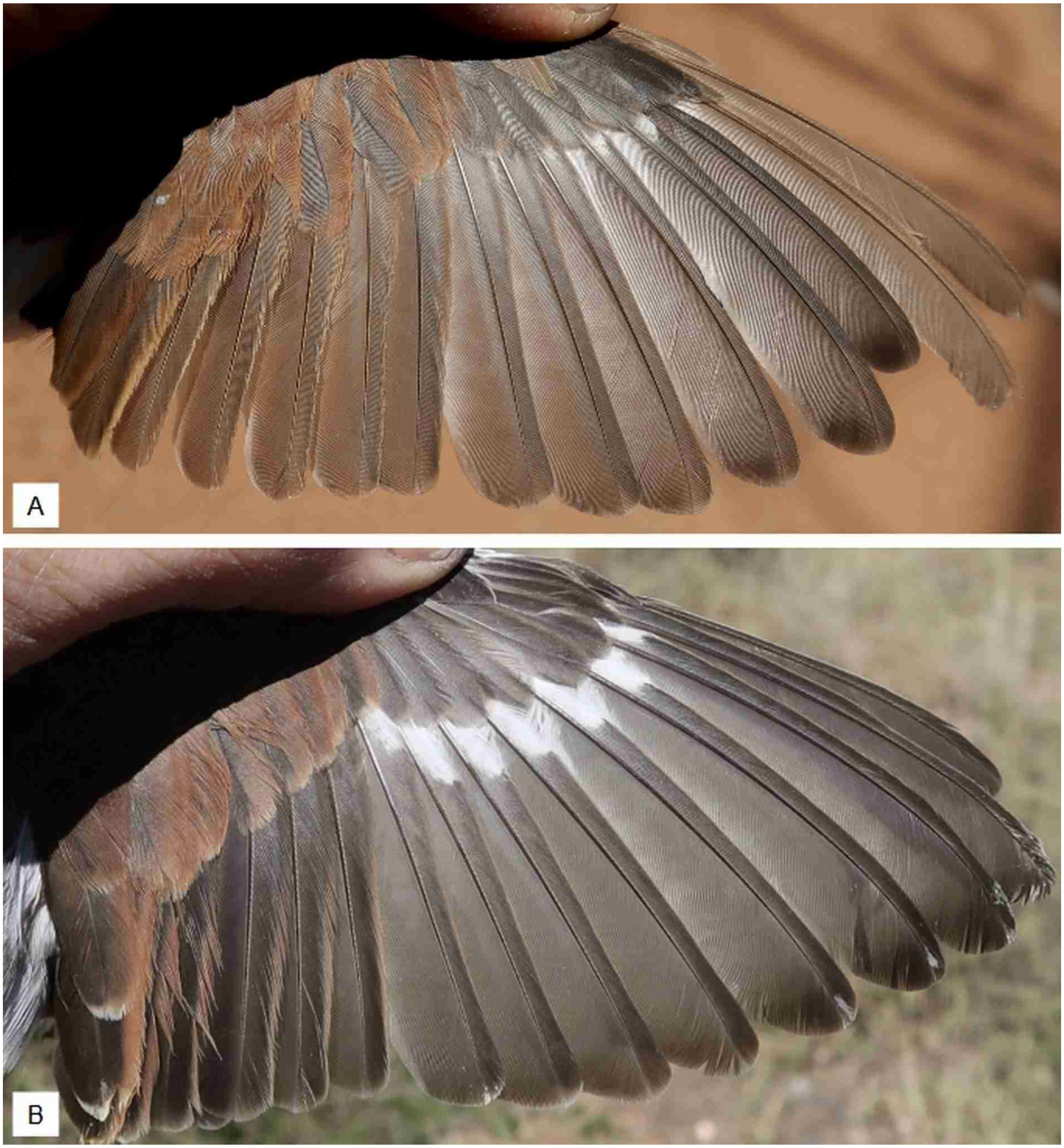


Figure 34. Adult males with variable size of the primary patch. (A) 8 January 2023. (B) 18 March 2023.

by Stresemann (1920) in Bub (1981, p. 115), Shirihai & Svensson (2018, p. 185), Lefranc & Worfolk (2022, p. 216), and Kauzál from the Czech Republic who recorded at least 25% in males (personal communication, 2022).

9. Breeding in Africa?

Migratory Palearctic bird species have been found to breed in southern Africa, including White Stork (*Ciconia ciconia*), European Bee-eater (*Merops apiaster*), and Booted Eagle (*Hieraaetus pennatus*; Yosef et al. 2000). For 150 years now, there are also claims of possible breeding of Red-backed Shrike in the southern hemisphere (Andersson 1872, p. 136; Roberts 1940, p. 299; Macdonald 1957, p. 143 [erroneously]; territorial behavior in Sauer & Sauer 1960, p. 73; Becker 1974, p. 76).

The occurrence of breeding in Africa goes undetected because it is not considered an option in the reality of field work and does not match our knowledge about this species. One individual was trapped in the Czech Republic in May

2020 by Ondrej Kauzál. It "looked like a bird in juvenile plumage. But considering the date of capture (beginning of May, actually it was at the time Shrikes began to appear that year), a bird in juvenile plumage is very unlikely" (2022, http://ondrejkauzal.org/gallery/_spec173-lan_col.html, individual CZEP20-149). The bird was aged "as a second year because of the much retained juvenile contour feathers" (ibid.) (Fig. 35). Possibly, we see here a female in particularly aberrant plumage (Norbert Lefranc, pers. comm.) More research is needed to resolve this question.

Acknowledgments

We thank those who supported us with pictures, publications, and discussions: Javier Blasco-Zumeta, Spain; Rob Bijlsma, Netherlands; Ondrej Kauzál, Czech Republic; Juan Carlos Hidalgo, Spain; Kim Hunt, SAFRING; Janine Dunlop, Niven Library in the FitzPatrick Institute of African Ornithology, UCT, Cape Town, and Norbert Lefranc, Reuven Yosef and Dries van Nieuwenhuyse for revision and editing. We are also grateful to the Namibian farmers who gave us generous access to their properties and the Namibian Ministry of Environment, Forestry and Tourism for granting the ringing permit.

References

Andersson, C. J. (1872) Notes on the birds of Damaraland and the adjacent countries of South-West Africa. John Van Voorst.

Becker, P. (1974) Beobachtungen an paläarktischen Zugvögeln in ihrem Winterquartier in Südwestafrika. SWA Wissenschaftliche Gesellschaft.

Blasco-Zumeta, J., & Heinze, G.-M. (2019) Red-backed Shrikes *Lanius collurio*. Identification Atlas of Aragon's Birds. Retrieved from http://blascozumeta.com/wp-content/uploads/aragon-birds/passeriformes/401.redbackedshrike-lcollurio.pdf.

Bruderer, B. (2007) Notes on the moult of Red-backed Shrikes *Lanius collurio* in their non-breeding range. Journal für Ornithologie, 148, 557–561. Retrieved from https://doi.org/DOI 10.1007/s10336-007-0190-9.

Bruderer, B., & Bruderer, H. (1994) Numbers of Red-backed Shrikes *Lanius collurio* in different habitats in South Africa. Bulletin of the British Ornithologists' Club, 114, 192–202. Retrieved from http://www.biodiversitylibrary.org/pdf4/038786600123710.

Bryson, U., & Paijmans, D. M. (2021) Common Fiscal *Lanius collaris* Linnaeus, 1766: Comparative biometrics, moult data and criteria for the determination of age and sex. Namibian Journal of Environment, 5 D, 1–23. Retrieved from https://nje.org.na/index.php/nje/article/view/volume5-bryson/volume5-bryson.

Bryson, U., & Paijmans, D. M. (2022) White-crowned Shrike *Eurocephalus anguitimens* A. Smith, 1836: Comparative biometrics, moult data and criteria for the determination of age. Namibian Journal of Environment, 6 D, 1–22. Retrieved from https://nje.org.na/

Figure 35. Red-backed Shrike in juvenile plumage, ringed in May in Europe. It was aged as second-year. It is undetermined if the major part of the plumage was retained from the previous year or if this is a bird that fledged in Africa. Czech Republic, 10 July 2022. Photo courtesy of Ondrej Kauzál.

index.php/nje/article/view/volume6-bryson/65e.org.na/index.php/nje/article/view/volume6-bryson.

Bryson, U., & Paijmans, D. M. (2023a) Mountain Wheatear *Myrmecocichla monticola*: comparative biometrics, moult and breeding data, and criteria for the determination of age and sex. Namibian Journal of Environment 7 D: 20–40. Online: https://nje.org.na/index.php/nje/article/view/volume7-bryson2/80.

Bryson, U., & Paijmans, D. M. (2023b) Red-backed Shrike *Lanius collurio* Linnaeus, 1758: Comparative biometrics, moult data and criteria for the determination of age and sex in the non-breeding grounds. Namibian Journal of Environment, 7 D, 1–19. Retrieved from https://nje.org.na/index.php/nje/article/view/volume7-bryson/79.

Bryson, U., & Paijmans, D. M. Lesser Grey Shrike *Lanius minor* Linnaeus, 1758: Comparative biometrics, moult data and criteria for the determination of age and sex in the non-breeding grounds. Namibian Journal of Environment, (in press).

Bryson, U., Paijmans, D. M. Boorman, M. (2023) Tractrac Chat *Emarginata tractrac*: comparative biometrics, moult data and criteria for the determination of age and sex. Namibian Journal of Environment 7: D-56. Online: https://nje.org.na/index.php/nje/article/view/volume7-bryson3/81.

Bub, H. (1981) Kennzeichen und Mauser europäischer Singvögel. Stelzen, Pieper und Würger (Motacillidae und Laniidae) (Vol. 2). Ziemsen.

Clancey, P. (1973) The status and character of the races of Red-backed Shrike wintering in the South-African subregion. Bulletin of the British Ornithologists' Club, 93, 92–96.

Cramp, S., & Perrins, C. (1993) Handbook of the birds of Europe, the Middle East and North Africa. The birds of the western Palearctic. Flycatchers to shrikes (Vol. 7). Royal Society for the Protection of Birds. Oxford University Press.

del Hoyo, J., & Collar, N. (2016) HBW and BirdLife International Illustrated checklist of the birds of the world. Passerines (Vol. 2). Lynx Edicions in association with BirdLife International.

Demongin, L. (2016) Identification guide to birds in the hand. The 301 species most frequently caught in western Europe. Identification, measurements, geographical variation, moult, sex and age. Beauregard-Vendon.

Dowsett, R. J. (Ed.) (2009) A contribution to the ornithology of Zambia. Turaco Press and Aves a.s.b.l.

Ginn, H., & Melville, D. (1983) Moult in birds (Reprint 1995). The British Trust for Ornithology.

Harris, T., & Franklin, K. (2000) Shrikes and Bush-shrikes. Including wood-shrikes, helmet-shrikes, flycatcher-shrikes, philentomas, batises and wattle-eyes. Christopher Helm.

Heinroth, O., & Heinroth, M. (1924) Die Vögel Mitteleuropas (Vol. 1).

Herremans, M. (2005) Red-backed Shrike *Lanius collurio*. In P. Hockey, W. Dean, & P. Ryan (Eds.), Roberts Birds of Southern Africa (7th ed., pp. 725–726). Trustees of the John Voelcker Bird Book Fund.

Hockey, P., Dean, W., Ryan, P. (Eds.) (2005) Roberts′ birds of southern Africa, 7th ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town.

Jenni, L., Winkler, R. (2012) Moult and ageing of European passerines. Christopher Helm, London.

Jenni, L., & Winkler, R. (2020a) Moult and ageing of European passerines (2nd edition). Christopher Helm.

Jenni, L., & Winkler, R. (2020b) The biology of moult in birds. Helm, Bloomsbury.

Kasparek, M. (1981) Die Mauser der Singvögel Europas. Ein Feldführer. (The moult of the passerines of Europe. A fieldguide.) Dachverband Deutscher Avifaunisten.

Kramer, G. (1950) Über die Mauser, insbesondere die sommerliche Kleingefiedermauser beim Neuntöter *Lanius collurio* L. Ornithologische Berichte, 3, 15–22.

Lefranc, N. & Worfolk, T. (2022) Shrikes of the world. Helm Identification Guide. London.

Paijmans, D. M., & Bryson, U. (2023) A comparison of measurements of passerine species and subspecies in Namibia. Afrotropical Bird Biology:
 Journal of the Natural History of African Birds, 3, 1–69. Retrieved from https://journals.uct.ac.za/index.php/ABB/article/view/v3_5.

Panow, E. (1983) Die Würger der Paläarktis. Gattung Lanius. A. Ziemsen Verlag.

Pârâu, L. G., Frias-Soler, R. C., & Wink, M. (2019) High genetic diversity among breeding Red-backed Shrikes *Lanius collurio* in the Western Palearctic. Diversity, 11(3), Article 3. Retrieved from https://doi.org/10.3390/d11030031.

Pârâu, L. G., Wang, E., & Wink, M. (2022) Red-backed Shrike *Lanius collurio* whole-genome sequencing reveals population genetic admixture. Diversity, 14(3), Article 3. Retrieved from https://doi.org/10.3390/d14030216.

Roberts A (1940) The birds of South Africa, 1st ed. The Trustees of the John Voelcker Bird Book Fund, London, Johannesburg.

SABAP - Southern African Bird Atlas Project 2. (2022) Regional changes in relative reporting rate—SABAP1 vs SABAP2 Shrike, Red-backed (*Lanius collurio*). Retrieved from https://sabap2.birdmap.africa/species/comparison/provincial/708.

Sauer, F., & Sauer, E. (1960) Zugvögel in Südwestafrika. Bonner Zoologische Beiträge, 11(1), Article 1.

Shirihai, H., & Svensson, L. (2018) Handbook of western Palearctic birds. Passerines: Flycatcher to Buntings (Vol. 2). Helm.

Skead, D. (1973) Red-backed Shrike returning to same wintering grounds. Ostrich 44: 81. Ostrich, 44, 81.

Snow, D. (1965) The Moult Enquiry 1. Bird Study, 12(2), 135–145. Retrieved from https://doi.org/10.1080/00063656509476095.

Stresemann, E. (1920) Avifauna Macedonica. Die ornithologischen Ergebnisse der Forschungsreisen, unternommen nach Mazedonien durch Prof. Dr. Doflein und Prof. L. Müller-Mainz in den Jahren 1917 und 1918. Dultz & Co.

Stresemann, E. (1963) The nomenclature of plumages and molts. The Auk, 80(1), 1–8. Retrieved from https://doi.org/10.2307/4082580.

Traylor, M. A. (1965) Birds of Barotseland and Bechuanaland. Ibis, 107, 137–172.

Yosef, R. (2008) Laniidae (Shrikes). In J. del Hoyo, A. Elliott, & D. Christie (Eds.), Handbook of the Birds of the World (Vol. 13, pp. 732–773). Lynx Edicions.

Yosef, R., & International Shrike Working Group. (2019) Red-backed Shrike *Lanius collurio*. Handbook of the Birds of the World Alive. Lynx Edicions, Barcelona. Del Hoyo J, Elliott A, Sargatal J, Christie DA, de Juana E (Eds.). Retrieved from https://www.hbw.com/node/60470.

Yosef, R., Verdoorn, G., Helbig A., Seibold I. (2000) A new subspecies of the Booted Eagle from Southern Africa inferred from biometricsand mitochondrial DNA. In: R. D. Chancellor & B.-U. Meyburgh (Eds.), Raptors at risk (pp. 43-49). Proc. 5th World Conf. on Birds of Prey and Owls.

European Journal of Ecology, 2024, 69-78

A CITIZEN SCIENCE PERSPECTIVE OF THE LANIIDAE IN ISRAEL

Reuven Yosef[1,*] and Jakub Z. Kosicki[2]

[1]*Ben Gurion University of the Negev, Eilat Campus, P. O. Box 272, Eilat 881020, Israel (ryosef60@gmail.com) ORCID 0000-0003-4331-9866*
[2]*Department of Avian Biology and Ecology, Adam Mickiewicz University, Poznań*
Uniwersytetu poznańskiego str. 6, 61 - 614 Poznań, Poland (kubako@amu.edu.pl) ORCID 0000-0002-9044-7775
***Corresponding author: E-mail: ryosef60@gmail.com*
Reviewers: Dries van Nieuwenhuyse, Norbert Lefranc

Abstract.

Citizen Science (CS) is currently widely used to collect data to assess large geographical areas and is advantageous in that the observations are random and independent, which collectively offer a database that is eclectic and free of professional biases. We availed of such a BioGIS database of the Hebrew University in Jerusalem and evaluated the status of the True Shrike (Laniidae spp.) in Israel. We found that in the Red-backed Shrike (Lanius collurio) the annual population growth rate (λ) in the exponential model for the entire period was 0.02 over 46 years; for the Great Grey Shrike (L. excubitor aucheri) was 0.07 over 53 years; for Isabelline Shrike (L. isabellinus) was 0.04 over 17 years; for Masked Shrike (L. nubicus) was 0.101 over 49 years; for Lesser Grey Shrike (L. minor) was 0.02 over 38 years; and for Woodchat Shrike (L. senator) was 0.11 over 48 years. Except for the decline in the breeding population of the Red-backed Shrike in Northern Israel, the rest of the species appear to be stable. Our study underlines the importance of CS for collating scientific data by the general public.

Key words: *BioGIS; Laniidae; temporal; geographical; distribution; Israel*

The Laniidae (True Shrikes) are a family of small to medium-sized birds that have evolved the unique behavior of impaling their prey (Yosef and Pinshow 2005). An African origin is suspected for the monogeneric family (*Urolestes*, *Corvinella*, *Lanius*), whose diversification occurred rapidly with the development of savannahs and other grassland habitats in Africa and in which migration evolved multiple times (Fuchs et al. 2019). True Shrikes are found on all continents except Antarctica, Australia and South America. True Shrikes are currently in decline in most regions of its global distribution for various, partly species-specific reasons (Yosef 1994, Tryjanowski et al. 2006, Kvist 2011, Duchardt et al. 2023). Therefore, monitoring programs aimed at obtaining information about population changes in this systematic group are needed.

Citizen Science (CS) currently widely used to collect data to assess large geographical areas and unlimited topics that can be addressed, all with minimal resources from the researcher (Yosef and Tryjanowski 2022). The digitization of observations also enables the compilation of species-specific data from the various open access platforms (Dylewski et al. 2017). The advantage of Citizen Science is that they are random and independent observations, which collectively offer a database that is eclectic and free of professional biases (Parsons et al. 2018, Reif et al. 2022). However, it should be borne in mind that data of this type can be biased due to methodological limitations – and therefore often need to use non-standard analysis methods.

Israel, located at the intersection of the three continents of Africa, Asia and Europe, is a biodiversity hotspot because it is typically located at the extreme edge of an organism's distribution (Rankevich and Warburg 1983, Sternberg et al. 2015). In Israel, Laniidae (*Lanius* spp.) studies have so far been limited either to general reviews in encyclopedias (e.g., Shirihai 1996) or to migration studies (Tryjanowski and Yosef 2002, Yosef et al. 2002, Aloni et al. 2021). The temporal and geographical distribution of the Laniidae has not been analyzed previously and little is known about their population trends in the Middle East in general and Israel in particular. Therefore, we used the BioGIS platform to download data on all seven Laniidae species observed in Israel over the past 50 years.

The species observed so far in Israel are Great Grey Shrike (*L. excubitor*), Southern Grey Shrike (*L. excubitor aucheri*), Red-backed Shrike (*L. collurio*), Isabelline Shrike (*L. isabellinus*), Masked Shrike (*L. nubicus*), Lesser Grey Shrike (*L. minor*), and Woodchat Shrike (*L. sena-*

tor). Also observed sporadically and considered extremely rare are the Turkmenistan/Red-tailed Shrike *(L. phoenicuroides;* 9 records*),* Long-tailed/rufous-backed Shrike *(L. schach)* and the Desert Grey Shrike (*L. e. pallidirostris*) but owing to the low numbers of these species we have not included them in our study. One *L. phoenicuroides* was ringed at the IBRCE research station in Eilat (Demongin and Yosef 2009), and the most recent records being from 2018 and 2021 (Israbirding.com 2023). However, the report by Demongin and Yosef (2009) was later corrected to be *L. isabellinus* (Panov 2011, page 543; N. Lefranc' Pers. comm.).

Updated information can be accessed at the website of Israel Birding which also includes the records of the Israeli Rarities and Distribution Committee (https://www.israbirding.com/checklist/).

However, we also draw attention to the fact that the Great Grey Shrike (*L. excubitor*) was considered a Holarctic species with about 20 subspecies, and data was collected as such in all studies and observations in Israel until the species was split into the Northern Grey Shrike (including North America), and the Southern Grey Shrike (*L. meridionalis*)(Isenmann and Bouchett 1993, LeFranc and Worfolk 1997, del Hoyo et al. 2008, Clements 2000, Harris 2000, Dickinson 2003, Panov 2011 but see Olsson et al. 2010) and even published as such (Keynan and Yosefa, b). However, *Lanius meridionalis* is now considered a monotypic species and called the Iberian Grey Shrike (Lefranc 2022; this volume), while all other earlier subspecies of the "Southern Grey Shrike" are again, as in the 1960s, considered subspecies of the Great Grey Shrike *Lanius excubitor*. Therefore, due to the ongoing debate surrounding the phylogeny of the *L. excubitor* group (Olsson et al. 2010), we merged the observations of the Southern Grey Shrike and the Great Grey Shrike under the local subspecies *Lanius excubitor aucheri*. However, it is possible that some of the observations may be of *L. e. pallidirostris* (N. Lefranc, pers. comm.).

The aim of this study is to model population trends of the six most commonly observed and reported Laniidae species in Israel.

Methods

Data collection

The data were downloaded from the BioGIS (2023) website operated by the Hebrew University in Jerusalem in collaboration with the Israel Nature and Parks Authority (INPA) and the Israel Ministry of Environment. This is a moderated database where each observation is reviewed by an academic team before being included and made available to the public for free and is open access. The database currently contains more than 2.5 million records from 6,269 species. We downloaded the data for the Laniidae on August 5, 2023.

In order to verify the conservation status of each of the species in Israel, we accessed the Israel Nature Risk Assessment Project (INRAP); https://redlist.parks.org.il/en/aves/detail/Lanius/, downloaded 20 December 2023. However, although this is the latest data available for Israel, its most recent update was 1 January 2011, i.e., almost 13 years ago. Additional information was collated from Shirihai (1996), Lefranc and Worfolk (1997), Harris (2000), Panov (2011), Lefranc (2022).

Information supplied pertaining to breeding or migration is based on published peer-reviewed papers only and not on compilations of sporadic or random observations (e.g., Paz 1987, Shirihai 1996).

Data processing

Individuals are not marked for individual identification, and we were unable to control for the effect of reporting the same individual multiple times in a year. Therefore, in order to minimize the likelihood of population overestimation, we combined observations into temporal-spatial groups. To do this, we divided Israel, the West Bank and the Gaza Strip into 5/5 km squares, thus obtaining 1255 grid cells (see: Hadad et al. 2023). Next, we assigned each observation to specific grid cells separately for each of the 45 study years, assuming that two or more reported individuals within a distance of no more than 500 m were sightings of the same individual. This procedure controlled to some extent the effect of bird observation randomness that is typical in citizen science data (cf. Reif et al. 2022).

Statistical analysis

To evaluate the trend analysis, we used generalized additive mixed models (GAMM), where the number of individuals in the given grid cells (y_{gr}) was considered as the additive effect of the year and those grid cells. In our modelling framework, we used the 'year' as a fixed factor (*f(year)*) and the grid cells as a random factor. The model was considered using the Poisson distribution. The model was considered in two variants: spline s and linear l. The differences between the two models were tested using likelihood ratio tests. The visualization of the trend was based on the *ptrend* algorithm included in the *Poptrend* library for R (Knape 2016).

In addition, we also calculated the annual population growth rate (λ) as an exponential model showing the statistical growth of the population per year (Mils 2013).

$$n_{y2} = n_{y1} \times \lambda^{(y2-y1)}$$

where: n_{y2} means number of individuals in year 2, while n_{y1} means the number of individuals in the year preceding $n_{y2.}$

Results & Discussion

In Israel, the longest data series is for *L. excubitor* (53 years Table 1), while the shortest is for *L. isabellinus* (17 years).

Table 1. Time series, linear and smooth population changes recorded for six *Lanius* spp. in Israel.

Species	Years	Linear estimated percent population change (95% CL)	Smooth estimated percent population change (95% CL)	Tau (p)
L. collurio	1977 - 2023	-16 (-70 – 165)	-60% (-96 – 422)	0.391 (0.0001)
L. excubitor	1970 - 2023	-9.8 (-51 – 105)	-17 (-90 – 575)	0.434 (<0.0001)
L. isabellinus	2005 - 2022	54 (-38 – 292)	3.4 (-69 – 296)	0.041 (0.847)
L. nubicus	1974 - 2023	42 (-47 – 299)	42 (-47 – 290)	0.485 (<0.0001)
L. minor	1985 - 2023	-52 (-83 - 17)	21 (-93 – 2082)	0.284 (0.024)
L. senator	1975 - 2023	21 (-34 – 134)	28 (-94 – 2683)	1.582 0.001)

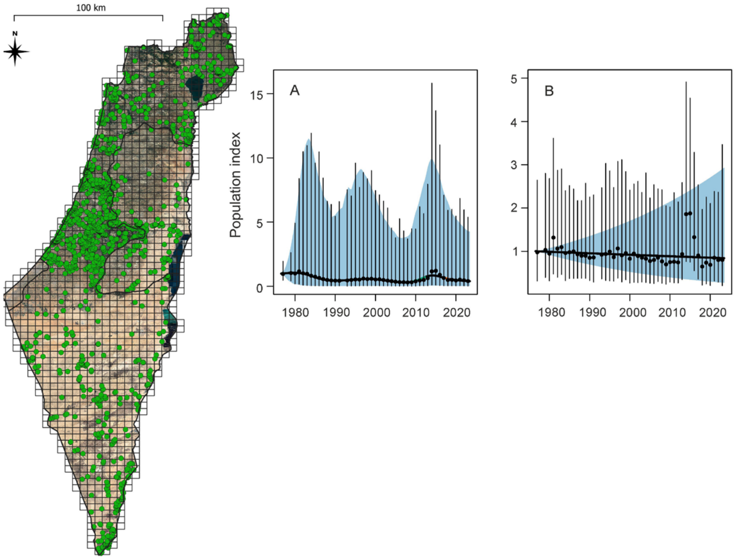


Fig. 1. Annual population trends for *Lanius collurio* in Israel based on GAMM with (A) smooth fit and (B) loglinear fit. Error bars show the standard error around the yearly estimates; black lines show trend fitted to the yearly point estimates, blue area represents 95% CL for the smooth fit. Map with dots showing the observation during 46 years of observations.

Lanius collurio

In Israel, the Red-backed Shrike is a common passage migrant throughout the country in spring and fall migration, and a summer breeder on Mount Hermon and in the northern Golan Heights and Upper Galilee (Israel Nature Risk Assessment Project; INRAP 2023). Its status is "Vulnerable" (V) due to its small and declining breeding population. The current population is estimated to be less than 1,000 adults and the rate of decline is estimated to >10% over 3 generations (12 years). It was classified as "Near Threatened" (NT) in the previous edition of the Red Book (2002). The change in the species' threat category reflects ongoing declines in population size and range (INRAP 2023). This is a little-studied species in Israel with only two papers on migration (Tryjanowski and Yosef 2002, Markovets and Yosef 2010). It is not marked as breeding in most of the family specific Shrike books (Panov 2011, Lefranc 2023) except by Lefranc (1997), Yosef (2008, 2020), and Harris (2000). In Lefranc (1997, 2023) isolated breeding populations are noted in the text on Mt. Hermon but not on the map.

During the 46-year of study, 2,942 individuals were recorded (Fig. 1) in 454 (36.2%) of the grid cells. The mean number of individuals per year was 65.3 (95% CL: 23.5 – 107.19) and was 6.48 per grid cell (95% CL: 4.59 – 8.36). The fewest individuals were observed in 1977 and 1993 (in both cases only 1 individual), while the most individuals were recorded in 2014 (670). We found a linear trend in the number of reported individuals over the past 46 years (tau = 0.391, p = 0.0001). However trend population modeling based on GAMM with "smooth" fit (R^2 = 0.014, Fig. 1A) showed that in Israel between 1977 and 2023 the population decreased on average by -60% (95% CL -96% - 442%), while the model with "loglinear" (R^2 = 0.017, Fig. 1B) fit also showed a decrease in the population trend but only by -16% (95% CL -70% - 165%). The difference between two models was not significant (LSR test, L.ratio = 2.16, P < 0.141). Finally the annual population growth rate (λ) in the exponential model for the entire period = 0.02 (95% CL: -0.32 – 0.37). Although we have not separated the breeding and migration season observations, our data corroborate the conclusions of the INRPA

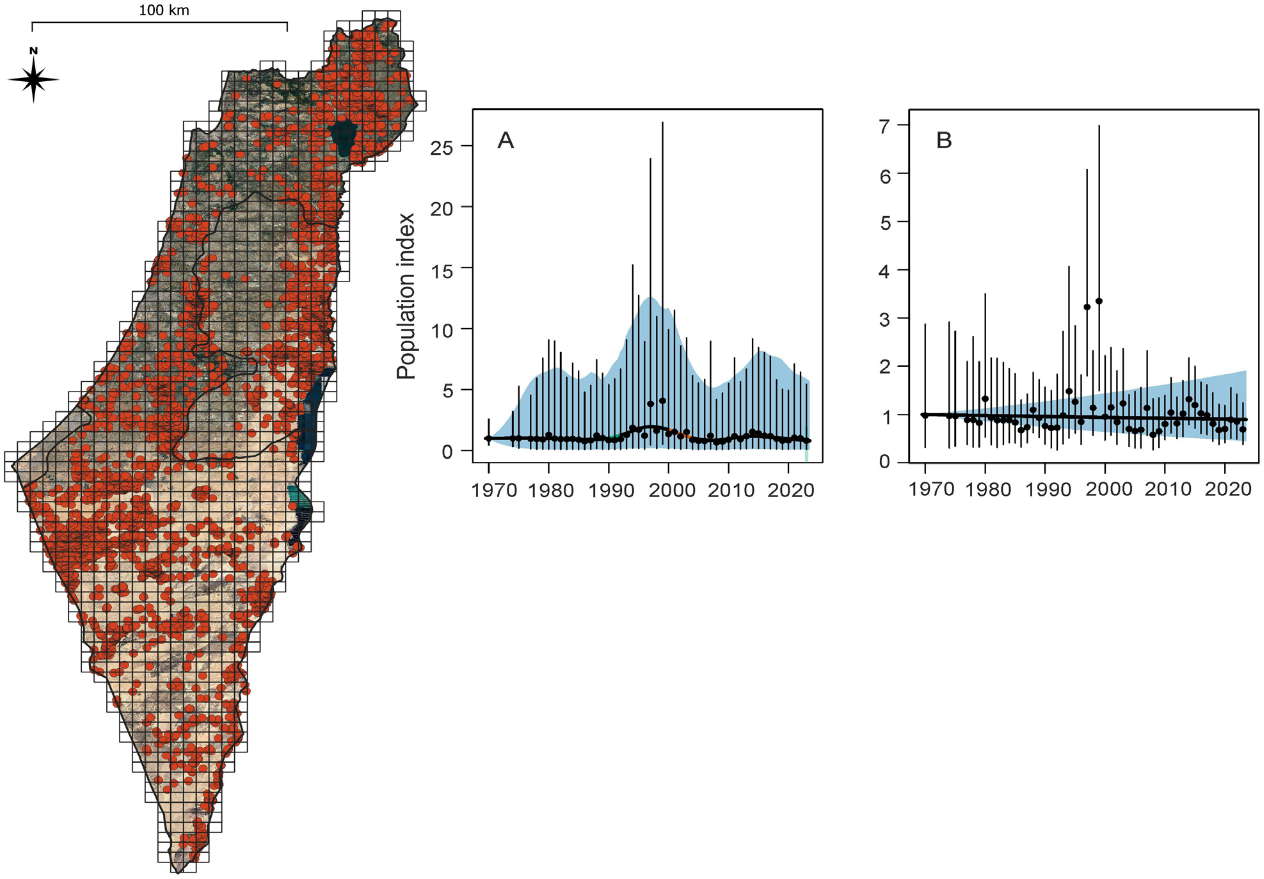


Fig. 2. Annual population trends for *Lanius excubitor aucheri* in Israel based on GAMM with (A) smooth fit and (B) loglinear fit. Error bars show the standard error around the yearly estimates; black lines show trend fitted to the yearly point estimates, blue area represents 95% CL for the smooth fit. Map with dots show the observation during all 53 years.

(2023) that the breeding population of the species in Israel is declining and justifies the risk assessment and the status "Vulnerable." INRPA believes that the main threat to Red-backed Shrikes in Israel is habitat modification due to development, afforestation and agriculture in the northern Golan Heights, as well as road construction and the development of ski runs and other facilities on Mount Hermon. In agricultural areas the species is likely to be affected by pesticides. However, no specific conservation measures have been taken for this species to date at the national level.

Lanius excubitor aucheri

In Israel the Levant (Great) Grey Shrike breeds throughout the country and is considered to be of "Least Concern" (INRPA 2023). In addition to the breeding population there is a hitherto unknown volume of the passage of migrants and also winter visitors (Shirihai 1996). Breeding in the species was studied in the desert regions of Sede Boqer (e.g., Yosef 1992, Yosef and Pinshow 1989, Degen et al. 1992) and Hatzeva (Keynan and Yosef 2010a, b).

As mentioned earlier, owing to the debate and uncertainty about the *Lanius excubitor*/*meridionalis* taxonomic status, we merged the observations of the Southern Grey Shrike (N = 36) and the Great Grey Shrike (N = 4,998) under the local subspecies, the Levant Grey Shrike *Lanius excubitor aucheri*.

Data for *L. e. aucheri* exists for the past 53 years, during which 5,034 individuals were recorded (Fig. 2) in 673 (53.6%) grid cells. The mean number of individuals per year was 100.6 (95% CL: 59.0 – 142.2) and 7.47 per grid cell (95% CL: 6.25 – 8.70). The fewest individuals were observed in 1970 - 1975 (in all cases only 2 individual), while the most individuals were recorded in 2014 (549). We found a linear trend in the number of reported individuals over the past 53 years (tau = 0.434, $p < 0.0001$). However trend population modeling based on GAMM with "smooth" fit ($R^2 = 0.057$, Fig. 2A) showed that in Israel between 1970 and 2023 the population decreased on average by -17% (95% CL -90% - 532%), while the model with "loglinear" (R2 = 0.035, Fig. 2B) fit showed an also decreased population trend but only by -9.8% (95% CL -51% - 105%). The difference between two models was not significant (LSR test, L.ratio = 0.192, $P < 0.661$). Finally the annual population growth rate (λ) in the exponential model for the entire period = 0.07 (95% CL: -0.11 – 0.28).

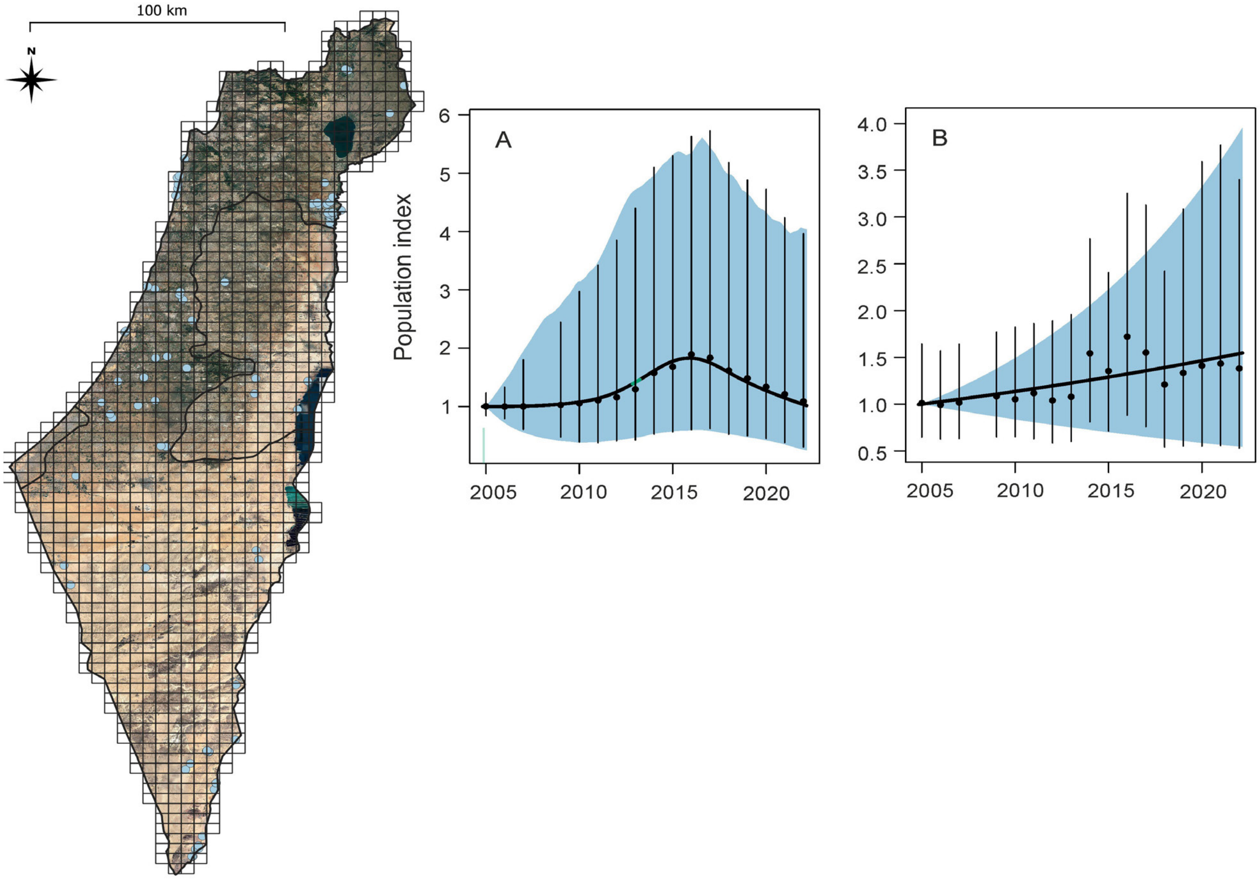


Fig. 3. Annual population trends for *Lanius isabellinus* in Israel based on GAMM with (A) smooth fit and (B) loglinear fit. Error bars show the standard error around the yearly estimates; black lines show trend fitted to the yearly point estimates, blue area represents 95% CL for the smooth fit. Map with dots showing the observation during the 17 years of observations.

Lanius isabellinus

Isabelline or Daurian Shrike is not included in Israel conservation status assessment (INRPA 2023). It is considered to be a passage migrant and winter visitor (Shirihai 1996).

Observations during the past 17 years include 109 individuals (Fig. 3) in 52 (4.1%) grid cells. The mean number of individuals per year was 6.41 (95% CL: 3.29 – 9.52) and 2.09 per grid cell (95% CL: 1.45 – 2.73). The fewest individuals were observed in 2005 – 2007 and 2020 (in all cases only 1 individual), while the most individuals were recorded in 2016 (18 individuals). We found no a linear trend in the number of reported individuals over the past 17 years (tau = 0.041, p < 0.847). However trend population modeling based on GAMM with "smooth" fit (R2 = 0.054, Fig. 3A) showed that in Israel between 2005 and 2022 the *L. isabellinus* population increased on average by 3.4% (95% CL -71% - 365%), while the model with" loglinear" (R2 = 0.056, Fig. 3B) fit showed an also increased population trend but by 54% (95% CL -39% - 271%). The difference between two models was not significant (LSR test, L.ratio = 0.001, P < 0.999). Finally the annual population growth rate (λ) in the exponential model for the entire period = 0.04 (95% CL: -0.39 – 0.48).

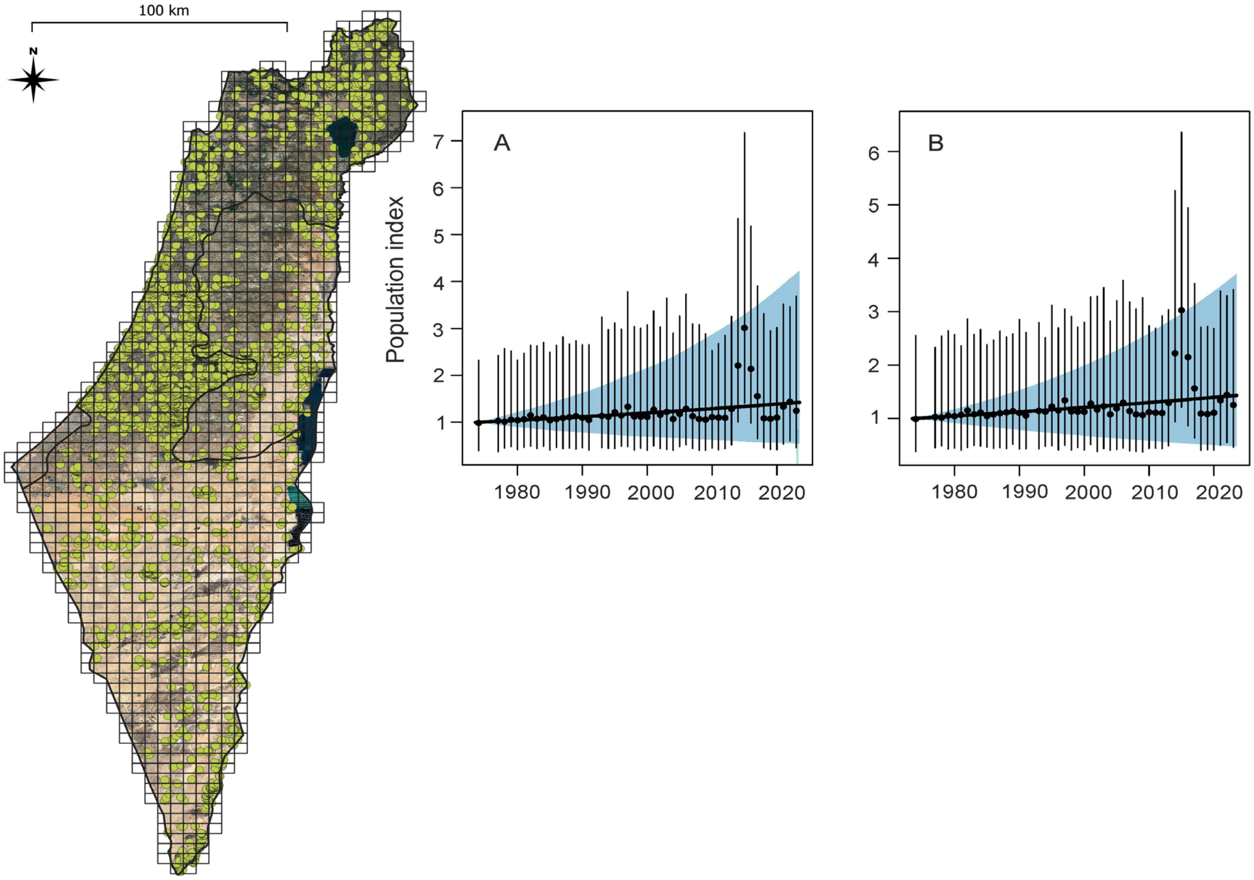


Fig. 4. Population trends for *Lanius nubicus* in Israel based on GAMM with (A) smooth fit and (B) loglinear fit. Error bars show the standard error around the yearly estimates; black lines show trend fitted to the yearly point estimates, blue area represents 95% CL for the smooth fit. Map with dots show the observations during the past 49 years.

Lanius nubicus

The Masked Shrike is considered to be of "Least Concern" in Israel with breeding in northern and central parts of the country (INRPA 2023), and passage migrant during the migration seasons (Shirihai 1996). The breeding biology of the species has not been studied in Israel, only migration strategies through ringing records (Yosef and Tryjanowski 2002, Aloni et al. 2021) and behavioral ecology (Yosef et al. 2012).

During the past 49 years, 4,260 individuals were recorded (Fig. 4) in 584 (46.5%) grid cells; the mean number of individuals per year was 90 (95% CL: 42.12 – 139.15) and 7.29 per grid cell (95% CL: 5.29 – 9.29). The fewest individuals were observed in 1974 and 1978 (in both cases only 1 individual), while the most individuals were recorded in 2015 (839 individual). We found a linear trend in the number of reported individuals over the past 49 years (tau = 0.485, p < 0.001). However trend population modeling based on GAMM with "smooth" fit (R2 = 0.042, Fig. 4A) showed that in Israel between 1974 and 2023 the *L. nubicus* population increased on average by 42% (95% CL -54% - 299%), while the model with" loglinear" (R2 = 0.066, Fig. 4B) fit showed an also increased population trend also by 42% (95% CL -48% - 261%). The difference between the two models were significant (LSR test, L.ratio = 10.39, P = 0.001). Finally the annual population growth rate (λ) in the exponential model for the entire period = 0.101 (95% CL: -0.85 – 0.62), indicating that on average the population of *L. nubicus* changed by 1% per year.

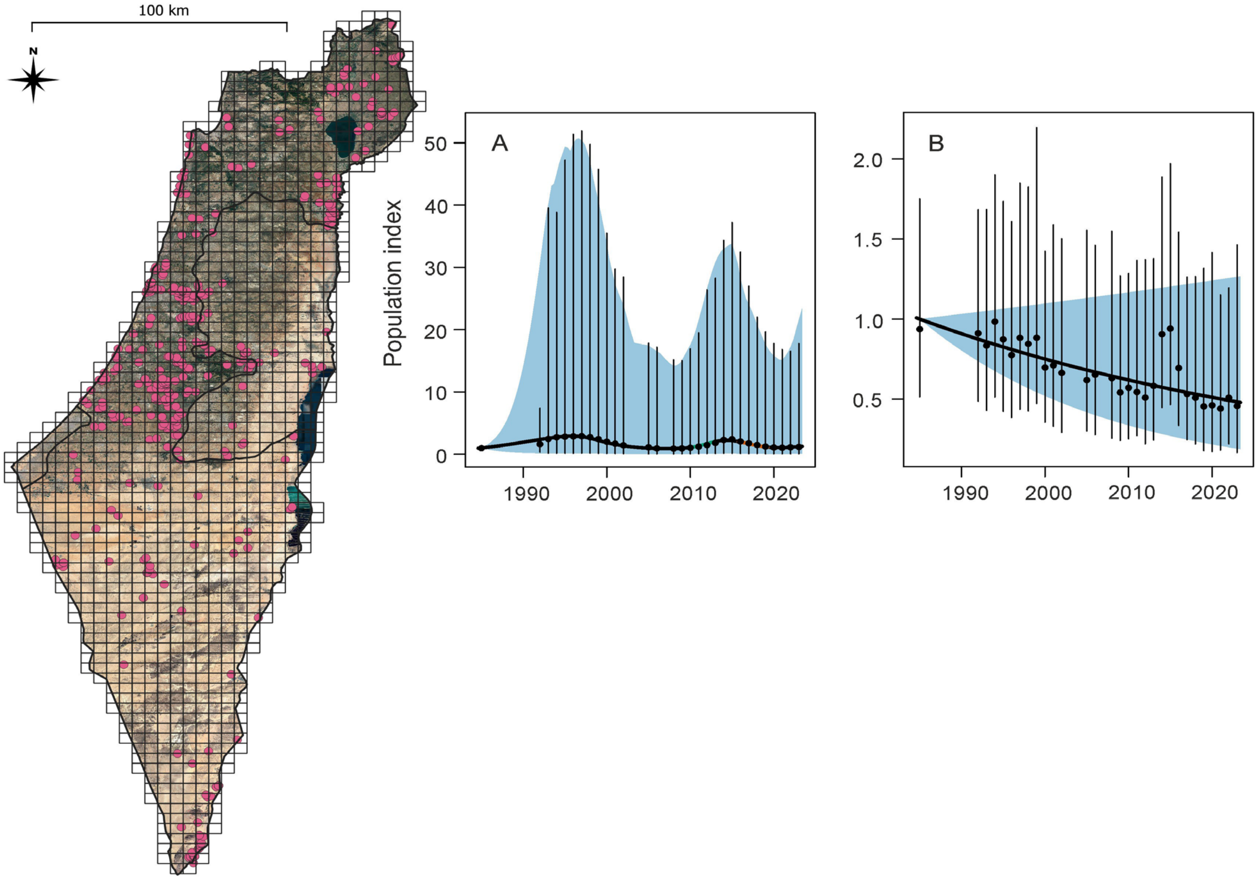


Fig. 5. Population trends for *Lanius minor* in Israel based on GAMM with (A) smooth fit and (B) loglinear fit. Error bars show the standard error around the yearly estimates; black lines show trend fitted to the yearly point estimates, blue area represents 95% CL for the smooth fit. Map with dots showing the observation during the 38 years of observations.

Lanius minor

In Israel the species is rarely observed, and is observed only on migration, hence no conservation status has been accorded (INRPA 2023). Some individuals may also summer but no breeding has been documented (Shirihai 1996).

The Lesser Grey Shrike was observed in Israel during past 38 years, in which 587 individuals were noted (Fig. 5) in 189 (15.1%) grid cells. The mean number of individuals per year was 19.56 (95% CL: 6.37 – 32.75) and 3.10 per grid cell (95% CL: 2.28 – 3.93). The fewest individuals were observed in 1985, 1996, 2001 and 2006-2008 (in all cases only 1 individual), while the most individuals were recorded in 2014 (155 individual). We found no linear trend in the number of reported individuals over the past 38 years (tau = 0.172, p =0.137). However trend population modeling based on GAMM with "smooth" fit (R2 = 0.034, Fig. 5A) showed that in Israel between 1985 and 2023 the *L. minor* population increased on average by 21% (95% CL -95% - 1432%), while the model with "loglinear" (R2 = 0.010, Fig. 5B) fit also showed an increase in the population trend by -52% (95% CL -80% - 19%). The difference between two models was not significant (LSR test, L.ratio = 0.950, P = 0.329). Finally the annual population growth rate (λ) in the exponential model for the entire period = 0.02 (95% CL: -0.32 – 0.37).

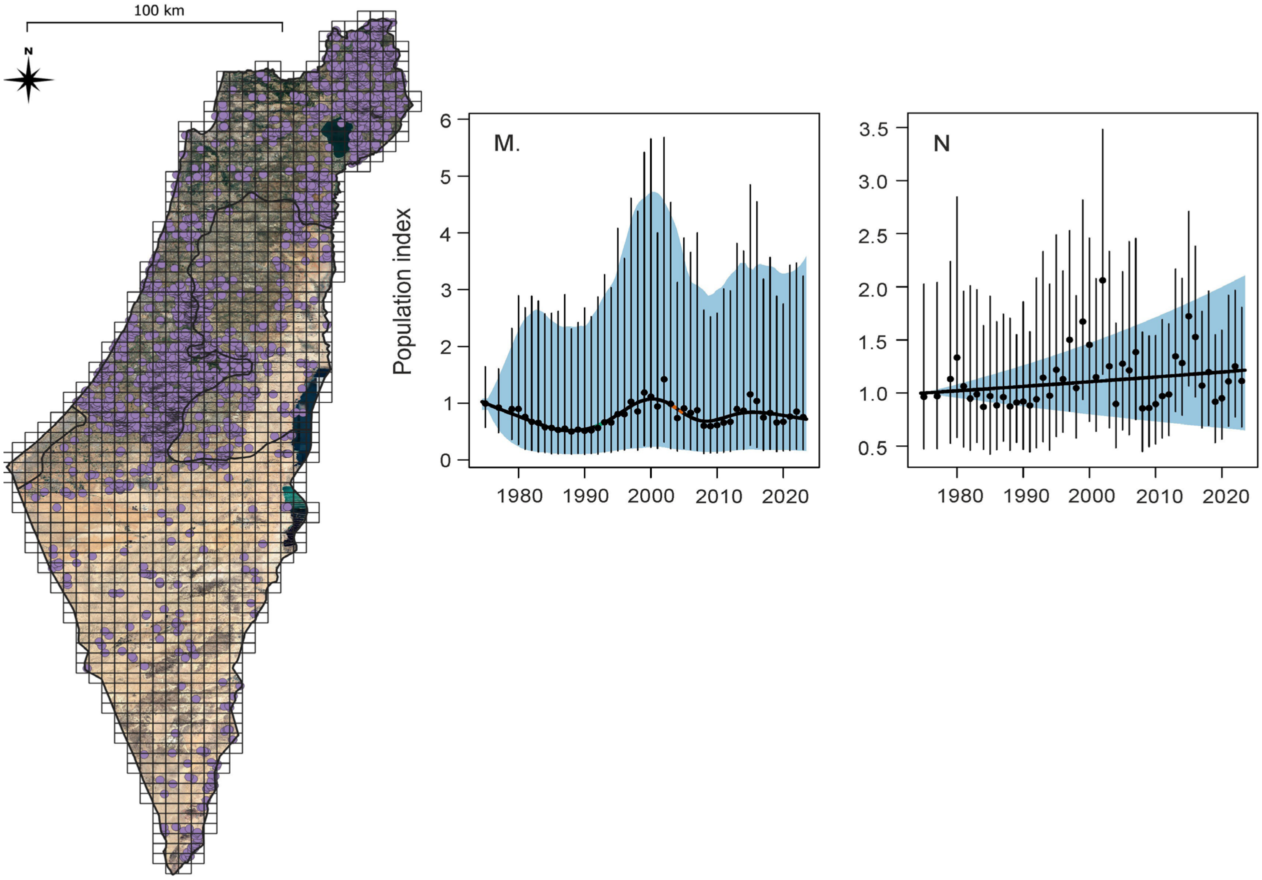


Fig. 6. Annual population trends for *Lanius senator* in Israel based on GAMM with (A) smooth fit and (B) loglinear fit. Error bars show the standard error around the yearly estimates; black lines show trend fitted to the yearly point estimates, blue area represents 95% CL for the smooth fit. Map with dots showing the observations during 48 years of study.

Lanius senator

The Woodchat Shrike is classified as of “Least concern” in Israel, as a summer breeder in northern and central Israel, and a migrant in the rest of the country (INRPA 2023). To date, the information about the breeding biology of the species is limited geographically (Inbar 1975, Shirihai 1996), and also the nominate subspecies on migration (Yosef and Tryjanowski 2000).

In the observations for the past 48 years, 3,853 individuals were recorded (Fig. 6) in 485 (38.7%) grid cells. The mean number of individuals per year was 81.9 (95% CL: 51.03 – 112.15) and 7.94 per grid cell (95% CL: 6.29 – 9.59). The fewest individuals were observed in 1975 and 1977 (in both cases only 1 individual), while the most individuals were recorded in 2015 (413 individual). We found a linear trend in the number of reported individuals over the past 49 years (tau = 0.582, $p < 0.001$). However trend population modeling based on GAMM with “smooth” fit (R2 = 0.019, Fig. 6A) showed that in Israel between 1974 and 2023 the *L. senator* population decreased on average by -27% (95% CL -82% - 231%), while the model with” loglinear” (R2 = 0.008, Fig. 6B) fit showed an also increased population trend also by 21% (95% CL -30% - 112%). The difference between two models was not significant (LSR test, L.ratio = 0.622, P = 0.430). Finally the annual population growth rate (λ) in the exponential model for the entire period = 0.11 (95% CL: -0.11 – 0.33). Our findings justify the Least Concern status for the species in Israel.

Methodological limitations and conclusions

However, it should be noted that our results may be biased. In particular, observations were assigned post-hoc to the grid cells. In addition, the method we use only allows, to a certain extent, multiple checks on the reporting of the same individual. Therefore, the estimate of the species population over the years may be over-estimated. It is therefore not surprising that the variability measures in our estimate are relatively large. However, by collecting data through citizen science, we were able to illustrate the situation of Lanidae population trends in Israel for the first time. Therefore, the presented picture of population changes should be considered as a first step in assessing population changes in this taxonomic group and planning more targeted field research methods.Despite methodological limitations our data confirm the conclusions and thus the conservation status of each Laniidae species in Israel with those of the official Israeli assessment, last updated on 1 January 2011. The only other data for comparison is even older, Shirihai (1996), Further, our study supports the idea of Citizen Science, the collection of data by laymen which is verified by professionals and then made accessible for use by the general public and academics, including this and similar studies.

References

Aloni I, Ziv Y, Markman S. 2021. Age- and sex-specific strategies of spring migration in the masked shrike are reflected in a differential response to winter climate conditions. *Climate Change Ecology* 2:100028. https://doi.org/10.1016/j.ecochg.2021.100028

BioGIS. 2023. *Israel Biodiversity Information System*. [http://www.biogis.huji.ac.il].

Clements, J.F., 2000. *Birds of the World. A Checklist*, fifth ed. Pica, Mountfield, Sussex.

Degen, A. A., B. Pinshow, R. Yosef, M. Kam, K. A. Nagy. 1992. Energetics in Northern Shrikes: nestling growth rate and field metabolic rates of adults. *Ecology* 73:2273-2283.

del Hoyo, J., Elliott, A., Christie, D.A. (Eds.), 2008. *Handbook of the Birds of the World*, vol. 13. Lynx Edicions, Barceolona.

Demongin, L., R. Yosef. 2009. Aberrant moult in an adult male Isabelline Shrike *Lanius isabellinus phoenicuroides*. *Sandgrouse* 31:160-162.

Dickinson, E. (Ed.), 2003. *The Howard and Moore Complete Checklist of the Birds of the World*, third ed. Helm, London.

Duchardt, C.J., Monroe, A.P., Edmunds, D.R., Holloran MJ, Holloran AG, Aldridge CL. 2023. Using neutral landscape models to evaluate the umbrella species concept in an ecotone. *Landscape Ecology* 38:1447–1462. https://doi.org/10.1007/s10980-022-01586-7

Dylewski, L., P. Tryjanowski, P. Mikula, F. Morelli, R. Yosef. 2017. Social media and scientific research are complementary - YouTube and shrikes as a case study. *The Science of Nature* 104:48-55. DOI 10.1007/s00114-017-1470-8

Fuchs J, Alstrom P, Yosef R, Olsson U. 2019. Miocene diversification of an open-habitat predatorial passerine radiation, the shrikes (Aves: Passeriformes: Laniidae). *Zoologica Scripta* 1-18. https ://doi.org/10.1111/zsc.12363

Fuisz, T. I., R. Yosef. 2002. Effect of habitat quality on hunting behaviour of breeding Great Grey Shrikes (*Lanius excubitor*). *Acta Zoologica Hungarica* 47:311-320.

Harris, T. 2000. *Shrikes and Bush-Shrikes*. Helm, London.

Inbar R. 1995. Shrikes nesting on Mount Hermon, Israel. In Shrikes of the world: Biology and conservation (Yosef R and F. E. Lohrer, Eds). *Proceedings Western Foundation Vertebrate Zoology* 6:215-217.

Isenmann, P., Bouchet, M.A., 1993. L'aire de distribution française et le statut taxonomique de la Pie-grièche móriodonale *Lanius elegans meridionalis*. *Alauda* 61:223–227.

Israel Nature Risk Assessment Project (INRAP); https://redlist.parks.org.il/en/aves/detail/Lanius%20/], downloaded 20 December 2023.

Keynan, O., R. Yosef. 2010a. Temporal and sexual differences of impaling behavior in Southern Grey Shrike (*Lanius meridionalis*). *Behavioral Processes* 85:47-51 (DOI: 10.1016/j.beproc.2010.06.005).

Keynan, O., R. Yosef. 2010b. Precipitation affects reproduction of Southern Grey Shrike (*Lanius meridionalis*). *Wilson Journal of Ornithology* 122:334-339.

Knape, J. 2016. Decomposing trends in Swedish bird populations using generalized additive mixed models. *Journal of Applied Ecology* 53:1852–1861.

Kvist L, giralt D, Valera F, Hoi H, Kristin A, Darchiashvili G, Lovaszi P. 2011. Population decline is accompanied by loss of genetic diversity in the Lesser Grey Shrike *Lanius minor*. *Ibis* 153:98-109.

Lefranc, N., Worfolk, T., 1997. *Shrikes: A Guide to the Shrikes of the World*. Pica Press, Mountfield, Sussex.

Lefranc, N. Worfolk T. 2023. *Shrikes of the World*. Helm, London.

Mills L.S. 2013. *Conservation of Wildlife Populations. Demography, Genetics, and Management*. Second Edition. Wiley–Blackwell, Oxford.

Olsson U, Alström P, Svensson L, Aliabadian M, Sundberg P, 2010. The *Lanius excubitor* (Aves, Passeriformes) conundrum – Taxonomic dilemma when molecular and non-molecular data tell different stories. *Molecular Phylogenetics and Evolution* 55: 347-57.

Panov, E. N. 2011. *The True Shrikes (Laniidae). Ecology, Behavior and Evolution*. Pensoft, Sofia. 910 pp.

Paz U. 1987. *The birds of Israel*. Christopher Helm, London.

Parsons AW, Goforth C, Costello R, Kays R. 2018. The value of Citizen Science for ecological monitoring of mammals. *PeerJ* 6:e4536. DOI 10.7717/peerj.4536

Rankevich D, Warburg MR. 1983. Diversity of bird species in mesic and xeric habitats within the Mediterranean region of northern Israel. *Journal of Arid Environments* 6:161-171. https://doi.org/10.1016/S0140-1963(18)31529-5

Reif J, Vermouzek Z, Voříšek P, Romportl D, Morelli F. 2022. Birds' ecological characteristics differ among habitats: an analysis based on national citizen science data. *Community Ecology* 23:173-186. https://doi.org/10.1007/s42974-022-00089-4

Shirihai, H. 1996. *The Birds of Israel*. Academic Press, Cambridge.

Sternberg M, Gabay O, Angel D, Barneah O, Gafny S, Gasith A, Grunzweig JM, Herhkovitz Y, Israel A, Milstein D, Rilov G, Steinberger Y, Zohary T. 2015. Impacts of climate change on biodiversity in Israel: an expert assessment approach. *Regional Environmental Change* 15:895-906. DOI 10.1007/s10113-014-0675-z

Tryjanowski, P., R. Yosef. 2002. Differences between spring and autumn migration of the Red-backed Shrike *Lanius collurio*: record from the Eilat stopover (Israel). *Acta Ornithologica* 37:85-90.

Tryjanowski P, Sparks TH, Crick HQP. 2006. Red-backed Shrike (*Lanius collurio*) nest performance in a declining Beitish population: a comparison with a stable population in Poland. *Ornis Fennica* 83:181-186.

Wood S.N. 2017. *Generalized Additive Models: An Introduction with R. Second Edition*. Chapman & Hall/ CRC, Boca Raton.

Yosef R. 1992. From Nest Building to Fledging of Young in Great Grey Shrikes (*Lanius excubitor*) at Sede Boqer, Israel. *J Ornithol* 133:279–285. https://doi.org/ https://doi.org/10.1007/BF01645637

Yosef, R. 1994. Conservation commentary: An evaluation of the global decline in the True Shrikes (Family Laniidae). *Auk* 111:228-233.

Yosef R. 2008. True Shrikes (*Laniidae*) – Family account. *Handbook of the Birds of the World*. Vol. 13, Pp. 732-796. Lynx Edicions, Barcelona, Spain.

Yosef, R., ISWG International Shrike Working Group, and D. A. Christie (2020). In *Birds of the World* (J. del Hoyo, A. Elliott, J. Sargatal, D. A. Christie, and E. de Juana, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.rebshr1.01

Yosef, R., P. Tryjanowski. 2002. Migratory Masked Shrikes *Lanius nubicus* staging at the desert edge: phenology, and sex- and age-related differences in body mass. *The Ostrich* 73:162-165.

Yosef, R., B. Pinshow. 1989. Cache size influences reproductive success in the Northern Shrike, *Lanius excubitor*. *Auk* 106:418-421.

Yosef R, Pinshow B. 2005. Impaling in True Shrikes (Laniidae): a behavioral and ontogenic perspective. *Behavioural Processes* 69:363-367. DOI 10.1016/j.beproc.2005.02.023

Yosef, R., P. Tryjanowski. 2000. Phenology and biometric measurements of migratory Woodchat Shrike (*Lanius senator*) at Eilat, Israel. *The Ring* (Proc. 3rd Int. Shrike Symp.) 22:213-217.

Yosef, R., P. Tryjanowski. 2022. Editorial: Perspectives in Education and Citizen Science in the next generations. *Frontiers in Ecology & Evolution* 10:847461. https://doi.org/10.3389/fevo.2022.847461

Yosef, R., P. Zduniak, P. Tryjanowski. 2012. Unmasking Zorro: functional importance of the facial mask. *Behavioral Ecology* 23:615-618. DOI: 10.1093/beheco/ars005

European Journal of Ecology, 2024, 79-92

SPECTACULAR INCREASE OF RED-BACKED SHRIKE (*LANIUS COLLURIO*) IN GAUME, SOUTHERN BELGIUM – EVIDENCE FOR NORTHWARD EXPANSION DUE TO STRUCTURAL CLIMATE CHANGE?

Dries Van Nieuwenhuyse* & Lore De Middeleer

Sint-Lievens-Esse (Herzele), Belgium
**Corresponding author: dries_van_nieuwenhuyse@hotmail.com*

Abstract.

After years of population decline across Europe, the Red-backed Shrike has made a remarkable recovery since the 1980s. In the agricultural area of Gaume (Belgian Lorraine), a significant population growth was recorded despite a continued decline in landscape quality. This shows that larger scale factors also influence the number and distribution of the species. We systematically monitored a breeding population of Red-backed Shrike during 1979-2015 and 2021-2022. Consistent growth was recorded until 1996. From 1999 to 2002, a land re-allotment project was carried out, leading to a significant decline, followed by a stable period until 2015. From 2020 onwards, new population increases were reported, leading to renewed survey efforts that resulted in a new significant and continuous increase in 2021-2023. Variations in climate appear to have played a crucial role in this striking evolution. Annual population numbers during 1980-2008 were compared with variations in climatic factors. Cold springs and wet summer periods appear to have a significant negative impact on breeder recruitment, suggesting that the species' breeding success may benefit from global climate change due to its higher breeding success rate, provided that the habitat is maintained and that its warming does not cause excessive rainfall during a critical period of its reproductive cycle. This paper describes the evolution of the Red-backed Shrike in Southern Belgium (Gaume) over four decades in relation to the evolution in neighboring countries or regions and in function of climate change.

Introduction

The Red-backed Shrike, a widespread breeding species across Europe and extending into Western Siberia between latitudes 40°N and 64°N (reaching 36°N in the southwest), inhabits (semi-)open natural and anthropogenic landscapes where it preys upon large insects and small vertebrates from perches. Predominantly, the population resides in Eastern Europe, with Romania, Poland, Bulgaria, and Russia collectively harboring 75% of the total European population (BirdLife International, 2015). While the species exhibits its highest probabilities of occurrence in Eastern and Southeastern Europe, occurrences diminish towards the North and West. The distribution of the Red-backed Shrike is influenced by climatic constraints, with avoidance of excessively dry and warm conditions in the South and regions of high precipitation and low summer temperatures in the North and Northwest, which can adversely affect reproductive processes (Schaub et al., 2011; Søgaard Jørgensen et al., 2013).

Following a period of population decline across Europe, the Red-backed Shrike has undergone a notable resurgence since the 1980s. Noteworthy expansions have occurred in central Spain, particularly in its southwestern and southeastern regions, as evidenced between EBBA1 (Fornasari, Kurlavicius & Massa In: Hagemeijer & Blair, 1997) and EBBA2 (Nijssen In: Keller et al., 2023), contrasting with prevailing negative trends (Telleria, 2018). Similarly, expansions have been observed in Western Europe, specifically in Western and Northwestern regions including France, Belgium, and the Netherlands. Conversely, losses have been documented in other Mediterranean regions such as Italy (including Sardinia) and Greece, potentially indicating a retreat from coastal areas. In Nordic countries like Norway and Sweden, gains and losses appear to have reached equilibrium (Fig. 1).

In the agricultural landscape of Gaume, situated in Belgian Lorraine, despite ongoing deterioration in landscape quality, a substantial increase in the Red-backed Shrike population has been documented. This phenomenon underscores the impact of broader-scale factors on the species' abundance and distribution. Our study involved systematic monitoring of a breeding population of Red-backed Shrike spanning from 1979 to 2015 and from 2021 to 2022. The recorded growth remained consistent until 1996. However, a notable decline occurred between 1999 and 2002 following a land re-allotment project. Subsequently, a period of stability ensued until 2015, with new population increases noted from 2020 onward. These recent increases prompted renewed survey efforts, revealing a significant and continuous rise in population size from 2021 to 2023. Climate variations have emerged as a key factor influencing this remarkable evolution. Comparative analyses of annual population data from 1980 to 2008 in relation to climatic variables indicate that cold springs and wet summer periods exert a substantial negative impact on breeder recruitment. These findings suggest that the species' reproductive success may be bolstered by global climate change, given its potentially higher breeding success rate, provided habitat preservation is maintained and warming trends do not result in excessive rainfall during critical reproductive periods.

This paper presents an account of the Red-backed Shrike's evolutionary trajectory in Southern Belgium (Gaume) over four decades, contextualized within the

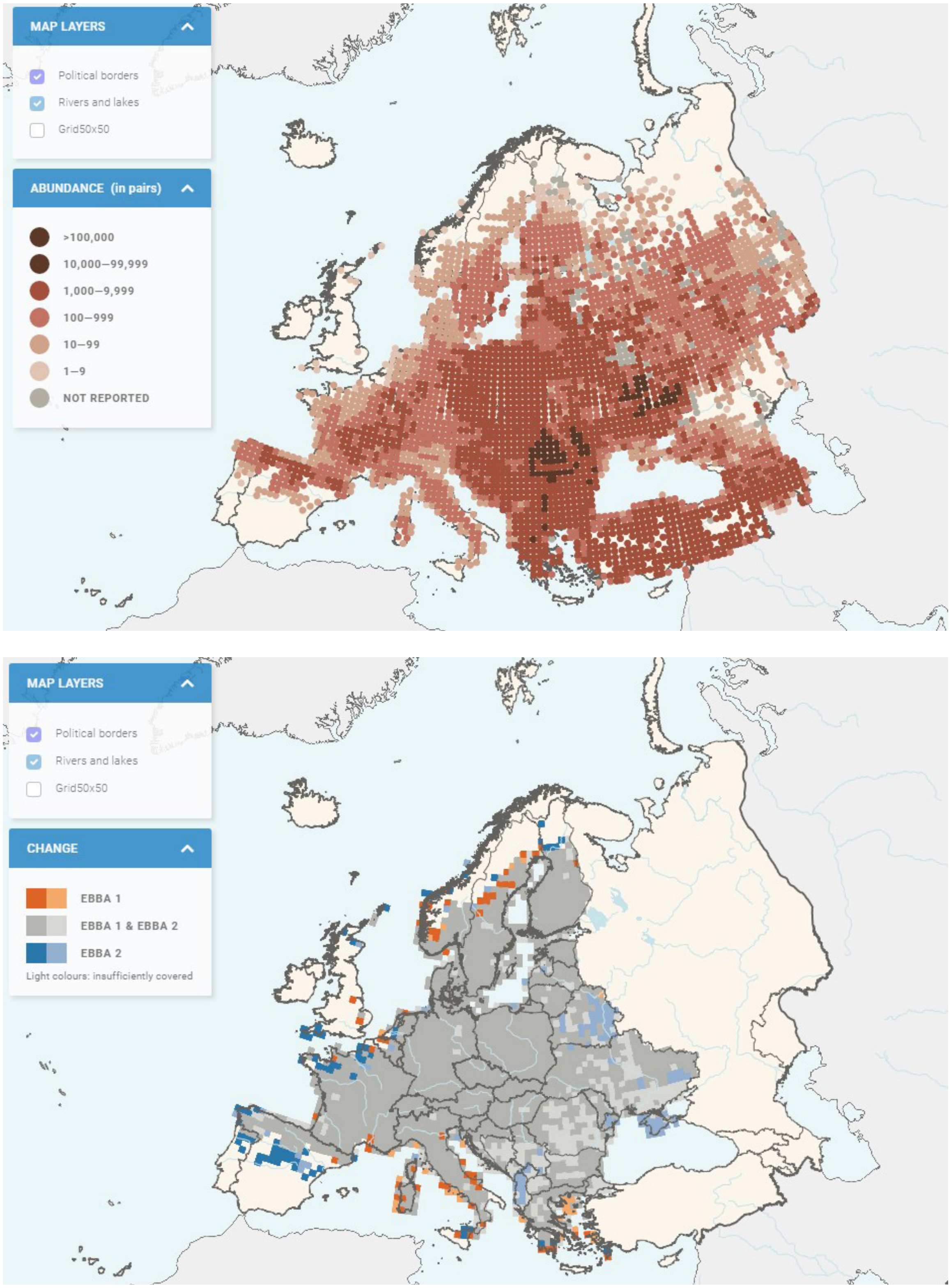


Figure 1. European distribution of Red-backed Shrike in 50 X 50 km grid cells (after Keller et al, 2020). A) Abundance B) Evolution EBBA1 (Hagemeijer & Blair, 1997) versus EBBA2 (Keller et al., 2023).

broader evolutionary patterns observed in neighboring countries or regions and in the context of climate change

Figure 1. European distribution of Red-backed Shrike in 50 X 50 km grid cells (after Keller et al, 2020). A) Abundance B) Evolution EBBA1 (Hagemeijer & Blair, 1997) versus EBBA2 (Keller et al., 2023).

Methods

Study area

The study area is situated in Southern Belgium, specifically in the Gaume region (see Figure 2). This region harbors one of Belgium's most significant populations of Red-backed Shrikes, estimated at 750-1150 territories in Belgian Lorraine during the period of 2001-2007 (Titeux et al., 2010). The landscape features a rolling relief and comprises predominantly grasslands, arable land, and forested areas. The grasslands are extensively grazed or utilized as hay fields. Agricultural activities primarily focus on meat production, with a discernible trend towards intensification (Mottiaux, 2003). Notably, the region retains characteristic elements such as calcareous grasslands, thereby augmenting its biodiversity value.

Approximately 51% of the municipality of Rouvroy, encompassing Couvreux, falls within the Natura 2000 designation. Specifically, the site BE34066 – Vallée du Ton & Côté Bajocienne Montquintin – Ruette spans an area of 3056 hectares.

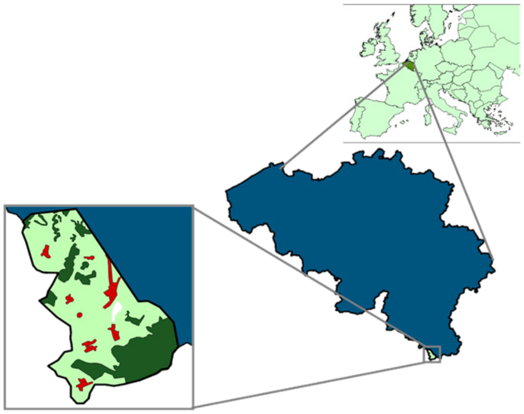


Figure 2. Situation of the study area in S Belgium. The study area covers 5000 hectares of which one third is classified as Natura 2000.

In approximately one-third of the study area, a land re-allotment project was implemented in Couvreux between 1999 and 2002, resulting in a significant alteration of the landscape (Fig. 3). This initiative led to a fundamental increase in the average size of land parcels, accompanied by an 84% reduction in the number of cadastral plots, whereas in non-re-allotted regions, the number of plots remained unchanged (Mottiaux, 2003). However, the land re-allotment program exerted a detrimental impact on landscape structure, scale, and biodiversity, creating less favorable conditions for shrikes. Both the mean and median perimeter lengths experienced notable declines, decreasing from 253 meters to 217 meters and from 195 meters to 149 meters, respectively. Consequently, the total perimeter length decreased by 17%. Additionally, there was an 11% increase in the number of cows, with the average number of cows per farm rising from 65 to 107 (a 64% increase). Notably, while the number of dairy cows decreased by 30%, there was a substantial 77% increase in meat cows.

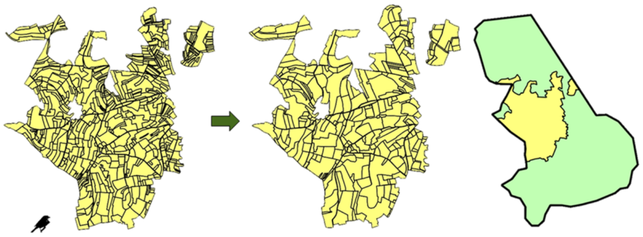


Figure 3. Land re-allotment area with parcel boundaries. Left, the situation before the land consolidation. Right, the situation after the land consolidation with significant increase in average plot size (after Mottiaux (2003).

From 1979 to 2015 and again from 2021 to 2023, annual surveys of Red-backed Shrike territories were conducted in Gaume, Southern Belgium, during the last week of June.

To investigate the potential impact of land consolidation on relative population numbers, the number of territories within the consolidation area was compared before, during, and after the consolidation period using proc GLIMMIX in SAS (Schabenberger, 2005).

To assess the influence of climate on annual population fluctuations, Partial Least Squares regression (PLS) modeling was employed. This involved the classification of variables using a latent variable approach, as described by Metzmacher and Van Nieuwenhuyse (2012).

Results

The population numbers of Red-backed Shrikes exhibited a notable upward trend, increasing from 7 territories in 1983 to a peak of 161 territories in 1996 (see Figure 4) (Van Nieuwenhuyse & De Middeleer, 2016, 2017a, 2017b).

Following the land re-allotment, the Red-backed Shrike population experienced a decline, stabilizing at around 90 territories from the early 2000s onwards, gradually rising to 98 territories by 2015.

The average proportion of shrikes within the land consolidation area decreased significantly from 42% to 36% after the land consolidation (t=2.62; p=0.0498) (Fig. 5; Van Nieuwenhuyse & De Middeleer, 2016).

Annual monitoring resumed in 2021 (n=140), revealing a growing population that reached 236 occupied territories by 2023, representing a 69% increase since 2021. Notably, between 2015 and 2023, the population experienced a remarkable 141% increase. Moreover, there was a 53% increase in population size between 2022 and 2023.

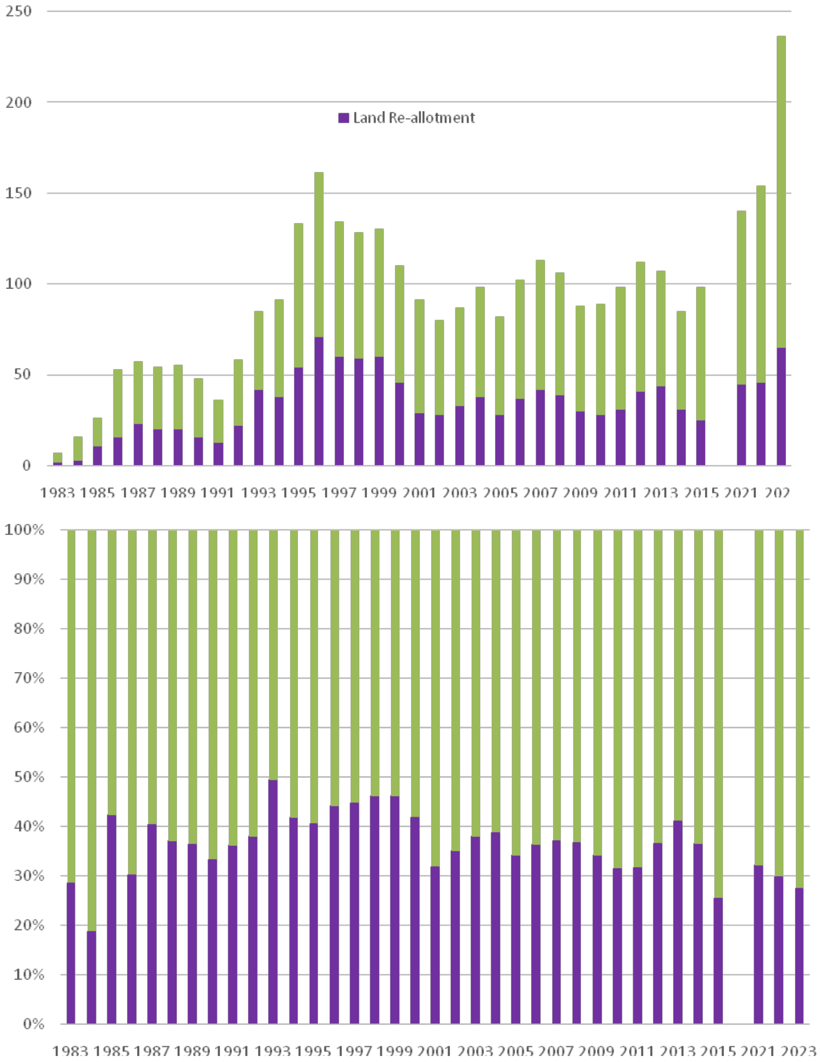


Figure 4. A) Evolution of the population size of Red-backed Shrike *Lanius collurio* in the study area in the Gaume 1983-2015 – 2021-2023. The land re-allotment scheme look place in 1999-2002. B) Evolution of percentage of Red-backed Shrike breeding in re-allotted and non-re-allotted part of research area.

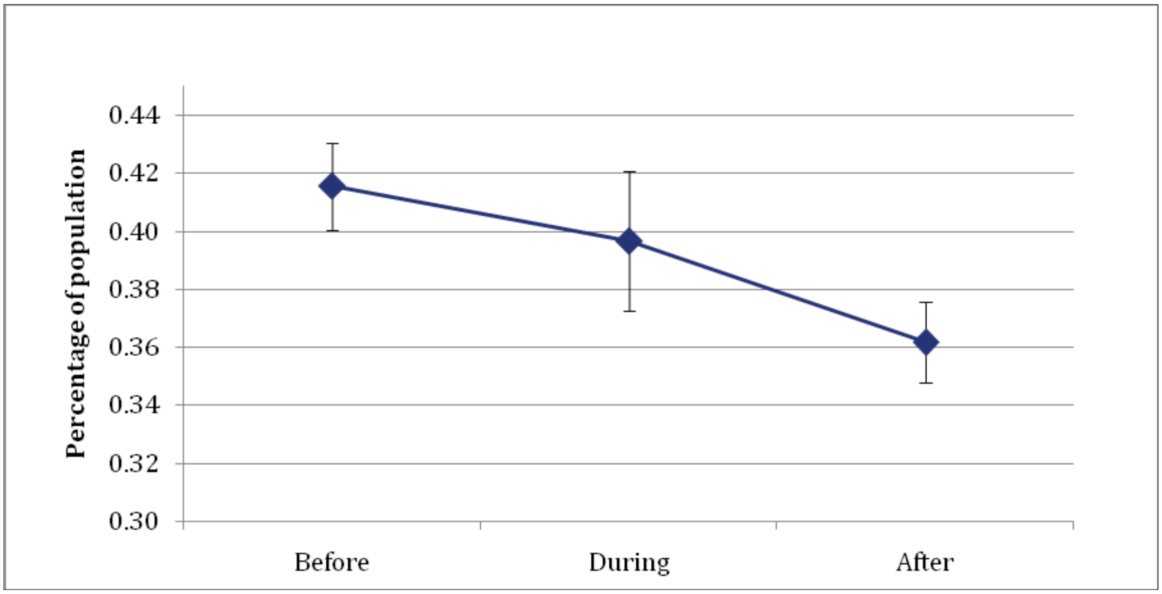


Figure 5. Average proportion of territories within the re-allotted area relative to the total.

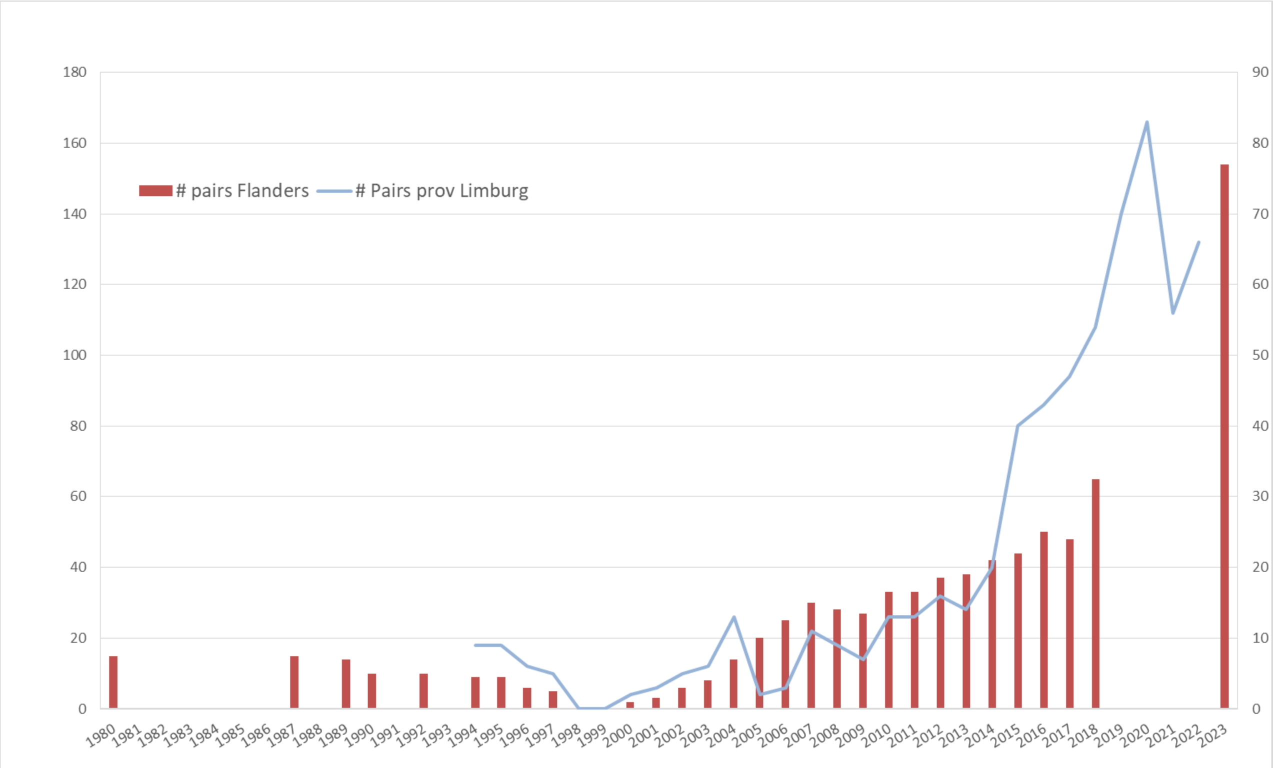


Figure 6. Evolution of Flemish Red-backed Shrike population as number of pairs (1980-2018) and as occupied 1 km² grid cells (2023).

In addition to land consolidation, variations in climate appear to have played a pivotal role in the observed evolutionary changes. To investigate this hypothesis, we conducted a comparative analysis of annual population fluctuations and variations in a series of climatic factors (Metzmacher & Van Nieuwenhuyse, 2012). This study draws from census data collected during the breeding period spanning from 1981 to 2008, utilizing weather data obtained from the nearest weather station to the study population.

Over the period of 1980 to 2008, the mean minimum temperature exhibited a tendency to increase during the April-August period. Additionally, rainfall intensity demonstrated a notable decline during the 1990s, followed by a significant increase in subsequent years. Furthermore, in the last three decades, rainfall intensity for June showed a decreasing trend, while that for August displayed an increasing trend. Notably, the annual variations of these monthly averages were found to be considerable.

Our research highlighted the considerable influence of various parameters associated with minimum temperature and precipitation during the breeding season on breeding population fluctuations. Specifically, cold springs and cool, wet summer periods were identified as factors significantly impacting breeder recruitment rates (Metzmacher & Van Nieuwenhuyse, 2012; Schaub, Jakober & Stauber, 2013). These findings suggest that the breeding success of the Red-backed Shrike could potentially benefit from global climate change, leading to an increased success rate of broods. However, this potential benefit is subject to the preservation of suitable habitat conditions, both in terms of quality and extent. Moreover, it relies on the condition that warming trends do not trigger excessively high rainfall during critical phases of its breeding cycle.

NEIGHBOURING COUNTRIES AND REGIONS

Flanders (Griet Nijs, personal communication)

In Flanders, the decline of the Red-backed Shrike traces back to the 1950s. While the Belgian population was estimated at 5,000 breeding pairs in 1950 (Lippens & Wille, 1972), it dwindled to 1,000 pairs by 1972, with only 350 pairs remaining in Flanders. Between 1973 and 1977, the number further decreased to a mere 570 breeding pairs, of which scarcely 110 were located in Flanders. During this period, the primary concentration of distribution was observed in the Kempen region, particularly in North Limburg, with only a few isolated breeding occurrences noted along the coast and in sandy Flanders.

The decline in Flanders accelerated during the 1980s, with the population fluctuating around 15 pairs (Maes et al., 1985). North Limburg, encompassing areas such as Lommel, Lozen, Sint-Huibrechts-Lille, Stamprooierbroek, Sint-Martensheide, and the Zwarte Beek valley, served as the last stronghold for a few years. However, even in these areas, the species continued to decline. By the early 1990s, breeding occurred sporadically outside of Limburg, with the population dwindling further to approximately 10 breeding pairs by 1992 (Vermeersch et al., 2004). In 1994, only nine territories were recorded throughout Flanders, with eight located in Sint-Maartensheide in North Limburg. Ultimately, this last population cluster was abandoned by the end of the 1990s, leading to the Red-backed Shrike being considered extinct in Flanders during the period of 1998-1999. Throughout the

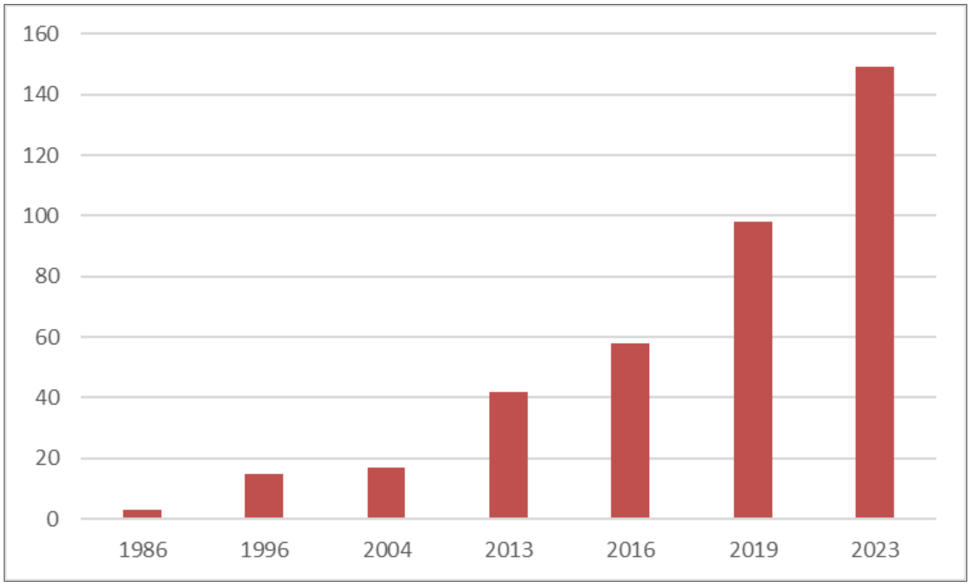


Figure 7. Evolution of breeding pairs in Natura 2000 site BE35027, Eau Blanche, Wallonia, S Belgium.

1990s, isolated breeding occurrences or territories were documented in various locations including the Zwinbosjes in Knokke (1992-1994), Sint-Huibrechts-Lille (1995), the Maatjes in Kalmthout (1996), and the dunes in Knokke (1996) (Vermeersch et al., 2004).

Since 2000, sporadic breeding occurrences have been observed, signaling a resurgence of the species in Flanders. The gradual recovery of the population was initially prominent in Limburg, where the Red-backed Shrike slowly expanded westward. By 2014, an estimated 20 breeding pairs were reported in Limburg.

Following this period, the Red-backed Shrike population experienced a significant resurgence (refer to Figure 6), coinciding with substantial habitat improvements within nature reserves (Nijs, 2020). Red-backed Shrikes are known to prefer diverse, semi-open landscapes characterized by species-rich grasslands with ample structural variation, providing an abundant food supply. Scattered thorny hawthorn, rose, and blackberry shrubs serve as both hunting perches and nesting sites. Consequently, the species thrives in extensively managed landscapes, serving as a vital ecological indicator for the quality of small-scale pastoral regions (van den Burg et al., 2011).

In twelve Flemish nature reserves, site managers implemented adjustments to nature management practices to meet the Red-backed Shrike's ecological requirements (Nijs, 2020). These measures aimed to enhance habitat quality through landscape improvements, with a focus on adjusting mowing management to increase prey availability and accessibility, restoring open landscape characteristics, and expanding potential breeding sites. Additionally, stacking branches to create piles provided additional hunting perches, while promoting the growth of hawthorn, rose, and blackberry shrubs between the branches offered supplementary breeding opportunities for shrikes.

The number of breeding pairs in Limburg increased significantly, reaching 66 breeding pairs by 2022, and their distribution expanded further. For instance, the number of 1 km² grid cells occupied by Red-backed Shrikes increased from 4 in the first decade (2000-2010) to 35 in the subsequent decade (2011-2020). Since 2020, there has been a notable acceleration in area expansion, with 154 grid cells occupied by 2023, and existing core areas are visibly densifying. Notably, the number of territories in core areas such as Sint-Maartensheide and the Voerstreek has increased to approximately 30 and 20-25 breeding pairs, respectively. Rapid increases have also been observed in other core areas, including Schulen (from 1 breeding pair in 2015 to 16 breeding pairs in 2023) and Diest (from 1 breeding pair in 2016 to 11 breeding pairs in 2023). This expansion trend is evident across Flanders, with recolonization observed in the Antwerp Kempen and sporadic breeding occurrences extending further westward, even into the Flemish Ardennes.

Wallonia (Jean-Yves Paquet, personal communication)

Red-backed Shrike monitoring has been conducted in Wallonia, Southern Belgium, specifically within the Natura 2000 site BE35027, which encompasses the Eau Blanche valley between Aublain and Mariembourg. This area, spanning 1300 hectares, is predominantly characterized by grassland habitats. The population of Red-backed Shrikes in this region has undergone significant evolution, increasing from a few pairs in 1985 to 149 territories in 2023, representing a substantial growth compared to the last census conducted in 2019 (see Figure 7).

This nature reserve has undergone continual evolution and improvement, largely attributable to its designation as a Natura 2000 area.

In 1996, the Red-backed Shrike population was low, and three distinct aggregates were observed: one in the southwest, situated within pasture meadows in a narrow section of the valley; another in the north, within a young spruce plantation; and the third in the south, within extensively managed meadows.

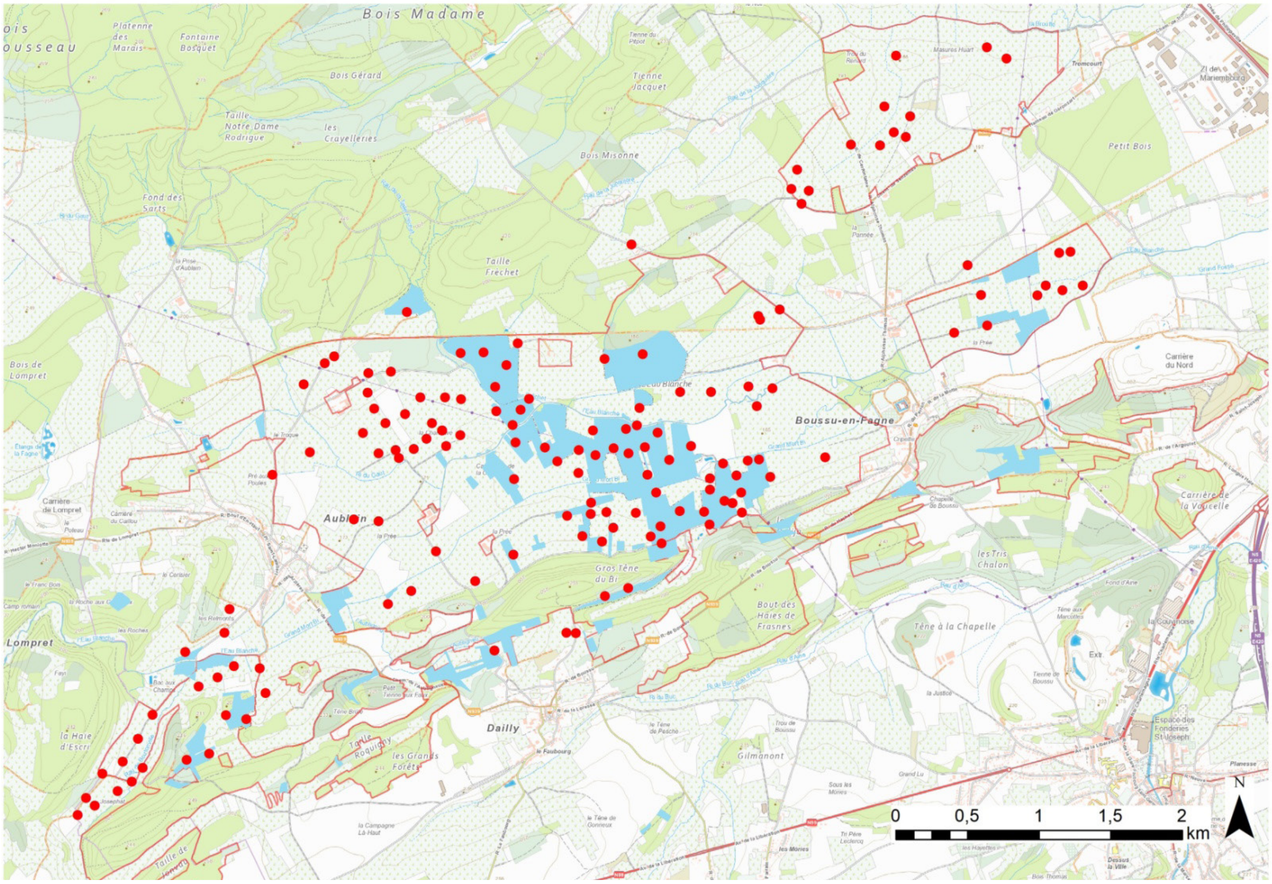


Figure 8. Red-backed Shrike breeding pair distribution in 2023 in Natura 2000 site BE35027, Eau Blanche valley between Aublain and Mariembourg. Existing nature reserve in blue.

By 2013, the nature reserve network had begun to develop, with a focus on the most ecologically significant meadows within the central part of the valley. The young plantation area was no longer favourable, while the central aggregate thrived around the extensively managed meadows and the reserve itself. Additionally, a new aggregate had formed in the east.

In 2023, following the implementation of the LIFE Prairies Bocagères project, a substantial portion of the central area had been preserved, constituting 10% of the entire Natura 2000 site. As a result, the Red-backed Shrike population now breeds throughout the reserve, including within the more intensively used pastures. Furthermore, even the north-eastern extension of the Natura 2000 site is now occupied by the species. It is anticipated that further increases in population are forthcoming (Jean-Yves Paquet, personal communication). Figure 8 illustrates the distribution of Red-backed Shrike pairs in 2023, a species that was virtually absent in the area three decades ago.

The population increase can be attributed in part to the progressive transformation of the landscape, facilitated by appropriate management practices. This transformation is evidenced by the increased length, continuity, and width of hedges, as well as the conversion of a growing number of pastures into haylands. In the case of the Eau Blanche area, it is believed that the nature reserve functions as a population source not solely because of its designation as a nature reserve, but rather due to the specific management practices implemented within these reserves that favor Red-backed Shrikes. These management efforts have created favorable conditions for the species, thereby contributing to its population growth.

Netherlands (Marijn Nijssen, Stichting Bargerveen, 2024)

The Bargerveen Foundation was established in December 1993 by the late Hans Esselink of the University of Groningen, with a primary focus on addressing a fundamental question: how did the population of the Red-backed Shrike in the Bargerveen experience a significant increase from the late 1980s onward, while the species vanished from the rest of the Netherlands? It was observed that the food supply for the species, including lizards, frogs, and large insects such as dragonflies, bumblebees, and grasshoppers, notably increased following rewetting measures that restored gradients in the peatlands, ranging from wet to dry, acidic to buffered, and nutrient-poor to nutrient-rich.

During the 1990s, the Red-backed Shrike population in Bargerveen declined again, primarily due to large-scale management efforts aimed at preventing peatland dehydration, which resulted in temporary habitat loss for the shrikes. At its lowest point just after the turn of the century, there were fewer than 100 breeding pairs in the Netherlands, half of which were in Bargerveen. The species appeared to be on the verge of disappearing from the country. However, from that juncture, the population in Bargerveen stabilized at around 50 breeding pairs, and small populations began to emerge in other areas of Drenthe, particularly in valleys and along the edges of peat bogs where nature restoration and optimization efforts were underway. Gradually, the species expanded further within the province, and there was also a noticeable increase in Limburg. Around 2015, it was estimated that there were approximately 200 breeding pairs in the Netherlands once again.

However, this increase did not occur uniformly. The long drought in the Horn of Africa in 2011 delayed the arrival of Red-backed Shrikes in breeding areas, and both 2011 and 2012 saw significant rainfall during the nesting period, resulting in low breeding success. This illustrated the species' sensitivity to weather extremes and the impact of climate change.

The majority of new settlements and expansions occurred in areas undergoing nature restoration and management, or where traditional landscape structures and farmland quality were restored. Examples include the De Maashorst area in North Brabant, the Fochteloërveen on the border of Friesland and Drenthe, and the arable areas around Muntendam in Groningen. These areas provided increased breeding opportunities and food supply, with slightly nutrient-rich conditions supporting significant insect biomass production while mitigating the acidifying effects of nitrogen deposition.

Since 2019, there has been an explosive increase in the Red-backed Shrike population in the Netherlands, attributed to a sequence of dry springs and summers, coupled with the expansion of suitable habitat through nature restoration and management. Research by Nijssen (2024) indicates higher numbers of fledglings and a greater proportion of first-year birds returning from Africa in subsequent years during this period. Between 2019 and 2023, the Dutch population more than doubled to over 700 breeding pairs.

The species in the Netherlands now appears to be out of the danger zone it faced at the end of the last century, thanks to significant habitat expansion, reducing dependence on a few vulnerable areas. Nature development and restoration, informed by research from the Bargerveen Foundation, have laid a solid foundation for the species' conservation. However, the future trajectory of the population remains uncertain. Continued warm and dry springs and early summers may lead to further population growth, while increased warm and wet weather due to advancing climate change could stabilize or even reverse population gains.

France (Raphaël Bussière, personal communication)

The population of Red-backed Shrikes in France is estimated to range between 100,000 and 200,000 pairs based on studies conducted between 2009 and 2012 (Caupenne et al., 2015; Bussière et al., 2022). The trend in the French population is characterized by fluctuations, as observed during the period from 2001 to 2012 (Caupenne et al., 2015). More recent data from Daviaud et al. (2023) focused on the former Poitou-Charentes region, comprising Charente (16), Charente-Maritime (17), Deux-Sèvres (79), and Vienne (86) departments, where the population ranged between 19,452 and 51,829 pairs, with an average of 29,882 pairs. The national population is classified as "near threatened (NT)" on the red list of threatened bird species in France (Colas et al., 2016), although there have been no updates to this classification since then.

The distribution of the Red-backed Shrike in France spans approximately two-thirds of the country. Significant increases have been noted in Northern France, particularly in Normandy (Deflandre, 2009), Picardy (Robert, 2020), Brittany (Couronné et al., 2017), Ille-et-Vilaine (Couronné et al., 2017), and Maine-et-Loire (Mourgaud and Logeais, 2012), with an extension of its distribution area. Additionally, Raphaël Bussière (personal communication) has monitored a population in Limousin, consisting of 41 to 67 breeding pairs within a 16 km² bocage sector, which has been increasing annually on average by 0.86 [95% CI: 0.21 - 1.52] from 2006 to 2023.

In other regions of France, the trends vary: the population in Haut-Rhin (Upper Doller valley) has remained stable (Ackermann, 2012), while in Haute-Savoie, there has been a slight decrease (Boisier, 2011), and in Alsace, a decline of 7% was observed over a period of 17 years (Muller, 2016).

Spain (Juan Carlos Tellería, personal communication)

In the Iberian Peninsula, the Red-backed Shrike maintains a significant presence across the northern half, primarily associated with the Eurosiberian region. Its distribution spans from the Pyrenees to the Cantabrian mountains, Galicia, Northern Portugal, and the northern part of the Iberian System, where its presence has been longstanding. However, the population of Red-backed Shrikes in Spain has experienced a notable decline over the last three decades, with a decrease of 54%, particularly evident in Northern Spain and Portugal. Nevertheless, this decline should not overshadow recent changes in its distribution area.

Similar to the colonization patterns observed in other species with a distinct Eurosiberian character, such as the Tree Pipit (Anthus trivialis), the Red-backed Shrike has expanded its range from populations in the northern Iberian System towards new favorable areas in the Central and southern Iberian Systems within the Mediterranean region. This expansion into previously unoccupied territories as summer breeding grounds was not observed until the late 20th century.

The primary factors contributing to the retraction of Red-backed Shrike populations in the north are attributed to the loss of optimal habitat and the accelerated decline in insect abundance across much of its range within the Eurosiberian region, including the Iberian Peninsula. These declines are primarily linked to agricultural intensification and land consolidation, as well as the widespread use of pesticides, resulting in the reduction of arthropod populations. Additionally, global-scale factors, such as climate change, may be altering productivity cycles in breeding areas within the Eurosiberian region, potentially driving the species towards mountain ranges, as observed in the

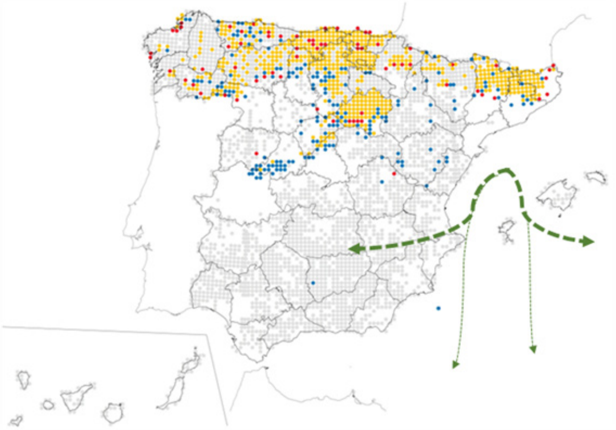


Figure 9. Biogeographic evolution of Red-backed Shrike in Spain during the last decades (Base map from III Atlas of birds during the breeding season in Spain. Moline et al. In SEO/BirdLife, 2022). Blue dots=New occupied grid cell; Yellow=re-occupied grid cell, Red= Abandoned grid cell.

central Iberian Peninsula. However, this trend requires further confirmation in other regions

The primary driver behind the new colonization of Central Iberia by the Red-backed Shrike is a combination of factors, including the favorable status of populations in the Iberian System at the distribution border, coupled with regional dynamics. In this context, the proximity of suitable habitat within approximately 80 kilometers, along with the absence of physical barriers, has facilitated the species' colonization of new territories, which may not necessarily be attributed solely to global warming.

However, climate change does play a role in affecting the retreat of mountain populations to the north of the Iberian Peninsula, particularly in the Spanish Eurosiberian area (Tellería, 2018). Similar to other species associated with mountain habitats, climate change leads to a reduction in habitat suitability and distribution range. Model projections indicate substantial contractions in the species' potential distribution, ranging from 89% to 92% between 2041 and 2070, with a significant decrease in the level of overlap between observed and potential distributions to a range of 6% to 10% during the same period (Araújo et al., 2011). Consequently, the conservation priorities for the Iberian Red-backed Shrike in the coming years should focus on gaining a better understanding of the retraction observed in the north and the expansion observed in Central Iberia.

EU assessments and Member States' data compiled as part of the Habitats Directive - Article 12 reporting process

Recently, detailed distribution and population estimates have been collected by the EU assessments conducted through Member States' data compiled as part of the Habitats Directive - Article 12 reporting process (European Environment Agency, 2021). These assessments covered the EU 27 for the period 2008-2012 and the EU28 for the period 2013-2018. Table 1 confirms countries where population increases have been documented. For instance, Belgium and the Netherlands exhibited both short and long-term increases in population numbers and distribution. Denmark witnessed a short and long-term expansion of distribution, while Finland, France, and Italy saw long-term distribution expansions. Additionally, Romania experienced a short-term population increase, and the Czech Republic observed a long-term increase.

It's worth noting that local positive trends may be obscured by the aggregation of data at the country or regional level. For example, monitoring in Grand Est, Eastern France (Lefranc, 2017) revealed a notable increase in the Villé valley. In 2014, Groscolas (2014, 2015 & 2016) identified 115 occupied territories, which increased to 174 in 2015, representing a 25% rise. Although there was a slight increase compared to 2015 in 2016, the factors believed to account for these variations include breeding success and habitat evolution. Despite the positive trend in the Villé valley, the overall trend in Alsace appears to be declining, as evidenced by a comparison of two surveys conducted 17 years apart (Müller 1998; Müller & Groscolas 2015). In 1998 and 2015, practically the same observers recorded the Red-backed Shrike in the same 30 communities, with numbers decreasing from 311 to 288 couples, indicating a 7% decline, despite 2015 being a favorable year. Similarly, in Alsace, census results as part of the monitoring of biodiversity indicators (SIBA) showed a drop from 209 territories in 2005 to only 169 in 2014, representing a 19% decrease (Müller, 2015). These local findings led to the classification of the species as vulnerable.

Discussion

The evolution in population numbers and distribution of the species can be attributed to several causes, including the impact of large-scale climatic changes on habitat selection and alterations in breeding biology induced by changes in local weather patterns during the breeding season, such as earlier arrivals and breeding, smaller clutch sizes due to adverse weather in May, among others. First, we will discuss the effects of large-scale changes in habitats, followed by an examination of changes in breeding biology parameters.

Shift to the North

On a broad continental scale, the breeding ranges of most bird species are primarily influenced by climate, either directly impacting the birds themselves or indirectly through its effects on habitat development and human land use patterns that favor specific species. By assessing the current climatic conditions within which each species resides in Europe (its 'climatic envelope') and predicting where those conditions may shift in the future, we can gain insights into potential future habitat distributions. Such predictions are valuable for speculation and conservation planning.

According to Huntley et al. (2007), by the end of the century, the breeding ranges of most species are expected to shift towards the north and northeast by approximately 500-1000 km. Models used for these predictions are calibrated with current distribution data and employ various climatic variables such as Mean Temperature of the Coldest Month (MTCO), degree days above 5°C (GDD5) representing overall warmth, and the Annual ratio of actual to potential evapotranspiration (AET/PET) as a measure of available moisture. These models take into account seasonal variations in precipitation supply and evaporative/transpirational demands, reflecting the moisture limitations experienced by organisms.

The Red-backed Shrike primarily breeds in regions where the annual temperature sum exceeds approximately 750 degree days above 5°C, the mean temperature of the coldest month is above approximately -17°C, and seasonal moisture deficit is not severe (AET/PET >= 0.6). It occurs less frequently in regions with lower temperature sums or severe moisture deficits. The upper limit of the coldest month mean temperature varies with temperature sum, ranging from approximately 7°C at 200 degree days to 4°C at 2000 degree days. The model developed by Huntley et al. (2007) demonstrates a very good fit (AUC= 0.982). For the Red-backed Shrike, the extent of its simulated potential future range compared to its present range is R=0.99, and the extent of overlap between its potential future and present distributions is O=0.81.

The model by Huntley et al. (2007) clearly indicates a northern shift in the Red-backed Shrike's range, except for the Iberian Peninsula, where a southern expansion was predicted, initially considered counterintuitive. However, subsequent observations have confirmed this predicted southward expansion, manifesting as colonization of central Iberia, as described by Telleria (2018), alongside a retreat to the north.

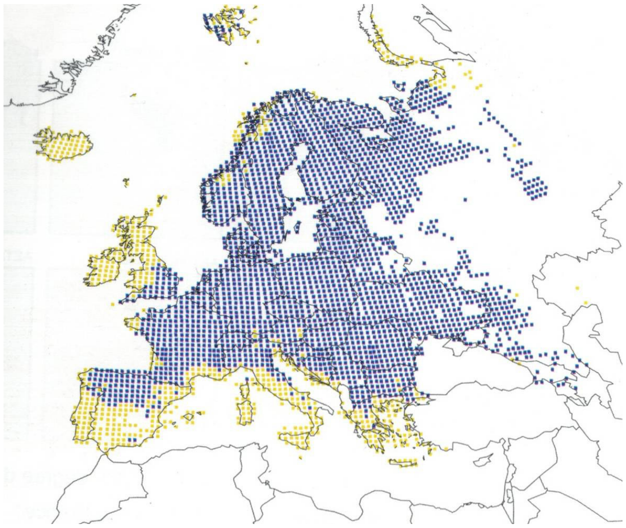


Figure 10. Potential late 21st century-distribution of Red-backed Shrike (after Huntley et al, 2007).

Agri-environmental schemes

Roilo et al. (2024) conducted a study to investigate the relationship between the occurrence probability of Red-backed Shrike in 2019 and the proportion of grassland-based agri-environmental schemes (AES), particularly examining whether this relationship differed between structurally simple and complex landscapes. They incorporated maximum temperature and the sum of mean monthly precipitation between May and July, sourced from the CHELSA Climatologies 1981-2010 V2.1 (Karger et al., 2020). The study compared three agricultural regions: Catalonia (Spain), Mulde River Basin (Germany), and South Morovia (Czech Republic), assessing their response to grassland-based agri-environmental management in relation to the probability of occupation by Red-backed Shrikes.

The effectiveness of AES was found to be higher in structurally simpler landscapes. Grassland, forest, AES, and the amount of small woody features (SHRUBS) were identified as significant positive predictors in all three regions. However, precipitation was only a relevant predictor in the German model, while maximum temperature was significant in the Czech model. The study suggests that the climatic impact on the probability of occupation is limited and may not be optimally modeled using aggregated climate data, especially considering the reliance on Red-backed Shrike data from 2019 alone, without considering the evolution of both dependent and independent variables over time.

Given that AES was not applied in the Gaume region and most of the positive population trends in neighboring regions are observed in managed nature reserves rather than agricultural areas, the authors do not consider AES as a relevant parameter for the current population fluctuations in Western Europe. This suggests that other factors, such as habitat management practices in nature reserves, may play a more significant role in influencing Red-backed Shrike populations in the region.

Changes in Breeding Biology

Metzmacher & Van Nieuwenhuyse (2012) found that a high minimum temperature during a large part of the breeding season is associated with an increase in the numbers of Red-backed Shrikes in the following year. They observed that temperature can influence various parameters of the nesting cycle and success, such as the timing of arrival, start of egg-laying, and brood success. For instance, warmer temperatures can lead to earlier returns and egg-laying, although this may negatively impact the success of the first clutches. However, in some areas, early nesting has been associated with larger clutch sizes, albeit with smaller eggs and lower fledging success.

In contrast, heavy rains have been linked to late returns and negative effects on clutch size, as well as potential abandonment of nests and decreased brood success (Lefranc, 1979, Hušek & Adamik, 2008). Moreover, continuous rain and low temperatures can result in nestling mortality due to cold exposure (Tryjanowski et al., 2000) and limit foraging trips by adult birds. These adverse weather conditions can also reduce the availability of food resources, leading to decreased breeding success and chick mortality (Müller et al., 2005, Antczak et al., 2009).

The abundance of large insects, such as Carabidae, is lower in drier environments, potentially affecting reproductive success. However, there may be a rainfall threshold below which reproductive success is penalized, highlighting the importance of habitats with sufficient moisture for breeding sites.

Overall, the links between local climate and annual fluctuations in Red-backed Shrike populations support the climatic hypothesis (Diehl & Myrcha, 1973), suggesting that a warming climate may have a beneficial effect on populations, provided it does not lead to excesses or deficits of rain (Avery & Krebs, 1984, Lehmann & Sommersberg, 1980). However, other factors such as habitat quality, land-use changes, and conditions in African stopover and wintering areas also play significant roles in population fluctuations

Heavy rains seem to determine the late returns of the Red-backed Shrike, such as those recorded in 2003 and 2005 in Marche-en-Famenne (van der Elst & Vieuxtemps, 2007). The state of the North Atlantic Oscillation (NAO), in February and March, on the other hand, does not seem to affect the chronology of the return (Hubálek, 2004). Showers or continuous rain can also soak the nests. When they contain nestlings, these nests are often abandoned, but replacement clutches are very common in the Red-backed Shrike (Lefranc, 1979; Antczak et al., 2009).

Heavy rains negatively influence clutch size in some females (Antczak et al., 2009). Furthermore, these bad weather conditions could cause a decrease in protein reserves in females. A fall in these reserves undoubtedly creates a stressful situation with an increased release of corticosterone. Via various mechanisms, this hormone can, for example, reduce the secretion of gonadotropin-releasing hormone (GnRH), at the level of the hypothalamus and, at that of the pituitary gland, the release of gonadotropins LH (luteinizing hormone) and FSH (folliculin) to ultimately inhibit the maturation of ovarian follicles (Sapolsky et al., 2000). In addition, these weather conditions can still affect the life expectancy of adults because, even under normal conditions, the reproduction has a cost.

The rainfall and the number of rainy days in May and June can also limit the brood success as was the case in northern Italy (Fornasari & Massa, 2000), in E Poland (Goławski, 2006) and locally in the Czech Republic (Hušek & Adamik, 2008). In the Swiss Alps between 1988 and 1992, on the other hand, Müller et al. (2005) did not detect any effect of climatic conditions on the reproductive performance of the species, but these conditions were perhaps not very rigorous during this study. Continuous rain, accompanied by low temperatures, can cause the death of nestlings due to cold, the birds no longer mobilizing their reserves quickly enough (Lefranc, 1979). Such conditions can also increase the length of trips linked to the foraging and reduce breeding success by limiting the accessibility or abundance of food resources (Hornman et al., 1998). It even happens that very large storms decimate certain populations of prey, like voles (Nesvadbova, 1992). Hence, climatic conditions of the breeding season in one year can affect the recruitment of breeders during the subsequent reproduction period (Olsson, 1995). Chick mortality would constitute the most negative effect on the viability of Red-backed Shrike populations (Takács et al., 2004).

The abundance of large insects such as *Carabidae*, for example, is lower in drier environments (Williams et al., 2008). If the abundance of rain limits reproductive success of the species, there could also be a rainfall threshold below which this success is penalized. It is undoubtedly no coincidence that the species prefers, as a breeding site, habitats with a certain degree of humidity (Titeux et al., 2007). The species is also less common in regions where moisture deficit is severe (Huntley et al., 2007). Overall, the links between local climate and annual fluctuations in Red-backed Shrike population numbers support the climatic hypothesis (Lefranc, 1979) and its variant, that of tap-hypothesis of Saether et al., 2004). These links also suggest that warming climate can have a beneficial effect on its populations, provided that it does not lead to excesses or deficits of rain. It could also encourage the extension towards the northern part of its range, as suggested by the simulation of its potential distribution future (Huntley et al., 2007). But, if climatic factors can influence the phenology and the reproductive success of the Red-backed Shrike, other variables such as the quality of habitat are likely to also modulate the size of its numbers and their geographical distribution.

Reasons for the population fluctuations might also be conditions in African stopover and wintering areas (Schaub et al, 2011, Tøttrup et al, 2011) and land-use changes, abandonment as well as intensification on the breeding grounds (Brambilla et al, 2010). The expected intensification of agricultural land use in E Europe countries will probably lead to loss and fragmentation of habitat and decline of food availability for this species of small-scale landscapes as happened in W Europe in the 20th century and possibly lead to a significant population decline in the future.

Land-use changes, including abandonment and intensification of agricultural practices, particularly in Eastern Europe, may lead to habitat loss, fragmentation, and decline in food availability, potentially resulting in a significant population decline in the future. Therefore, understanding the complex interplay between climate, habitat, and land-use changes is crucial for effective conservation management of Red-backed Shrike populations.

Immigration or local recruitment versus sources and sinks

The data collection focusing solely on population numbers without considering other demographic parameters such as breeding success, mortality, immigration, or emigration makes it challenging to determine the drivers behind population increases. The observed 53% increase in population numbers between 2022 and 2023 suggests that immigration may be a significant factor contributing to population growth, especially considering the lack of detailed breeding biology data in agricultural research areas.

Research by Schaub, Jakober & Stauber (2013) analyzed the dynamics of a Red-backed Shrike population in Germany over 36 years and found that immigration played a crucial role in preventing a strong decline in population size. Without immigration, the population would have decreased considerably, highlighting the importance of immigration for maintaining population numbers. Furthermore, they found that immigration was the primary driver for the number of females, while local recruitment played a key role in the number of males.

To better understand the relative importance of different demographic parameters and the colonization processes of newly occupied habitats, there is a need for research comparing breeding performance between habitats in agricultural areas and nature reserves. This research, similar to that conducted by Bloche et al. (2023), could elucidate whether population increases are driven by local recruitment, immigration, or a combination of both, in conjunction with habitat quality.

Understanding colonization processes and identifying source and sink habitats can inform conservation management strategies in nature reserves and agricultural areas. Implementing shrike-specific management practices in habitats with high potential for colonization could attract and support colonizing birds, potentially mitigating population declines in sink areas. Promising results from shrike-specific management experiments in Belgium and the Netherlands suggest that targeted management efforts within nature reserves and agricultural habitats could benefit Red-backed Shrike populations and facilitate their colonization towards the north (Nijssen, 2024, Nijs, 2020).

Conclusion

The spectacular population increases observed in the agricultural area of Gaume, despite negative landscape evolution due to intensification and land-reallotment schemes, align with the predicted northward shift of Red-backed Shrikes as indicated by climatic evolutionary models. This counterintuitive trend suggests that local climatic influences may be playing a significant role in driving population dynamics.

Interestingly, the impact of grassland agri-environmental schemes (AES) does not seem to have any effect on the Red-backed Shrike population in the Gaume region, nor in neighboring areas where similar population increases were primarily observed in nature reserves with shrike-specific management rather than agricultural areas. This discrepancy suggests that other factors, such as habitat quality and management practices specific to nature reserves, may be more influential in driving population growth in these regions.

The observation of population increases in agricultural areas despite landscape degradation highlights the complexity of species responses to environmental changes and underscores the importance of considering multiple factors, including climate, habitat quality, and management practices, in conservation planning and management efforts. Further research into the specific mechanisms driving population increases in both agricultural and nature reserve habitats could provide valuable insights for effective conservation strategies tailored to different landscapes and ecosystems.

References

Ackermann, L., 2011. Évolution d'une population de Pie-grièche écorcheur *Lanius collurio* et de son habitat dans la haute vallée de la Doller (Haut-Rhin) entre 1988 et 2009. Ciconia 3: 127-140.

Antczak, M., Golawski, A., Kuzniak, S. & Tryjanowski, P., 2009. Costly replacement: how do different stages of nest failure affect clutch replacement in the Red-backed shrikes *Lanius collurio*? Ethol. Ecol. Evol. 21: 127-136.

Araújo, M. B., Guilhaumon, F., Rodrigues Neto, D., Pozo Ortego, I., & Gómez Calmaestra, R. (2011). Impactos, vulnerabilidad y adaptación de la biodiversidad española frente al cambio climático. 2. Fauna de vertebrados. Dirección general de medio Natural y Política Forestal. Ministerio de Medio Ambiente, y Medio Rural y Marino, Madrid.

Avery, M. & Krebs, J., 1984. Temperature and foraging success of Great Tits *Parus major* hunting for spiders. Ibis 126: 33-38.

Birdlife International, 2015. European Red List of Birds. Luxembourg: Publications of the European Union.

Bloche, D.A.F., Thorup, K., Olsen, O., Ekberg, P., Ellegaard Larsen, P., Strange, K.-E. & Tøttrup, A.P., 2023. Breeding biology of Red-backed Shrikes (*Lanius collurio*): distribution, performance and post-fledging survival in Denmark. Ornis Fennica 100: 1–15.

Boissier, P., 2011. État de conservation de la Pie-grièche écorcheur (*Lanius collurio*) en Haute-Savoie. Bilan de l'enquête départementale 2009. Le Tichrodrome 16: 67-74.

Bussière, R., 2022. Pie-grièche écorcheur *Lanius collurio*, In: Dupuy, J. & Sallé, L. (eds.). (2022). Atlas des oiseaux migrateurs de France. LPO, Rochefort ; Biotope Éditions, Mèze ; Muséum national d'Histoire naturelle, Paris, 1122pp.

Brambilla, M., Rubolini, D., & Guidali, F., 2007. Between land abandonment and agricultural intensification: habitat preferences of Red-backed Shrikes *Lanius collurio* in low-intensity farming conditions. Bird Study 54: 160–167.

Caupenne, M., 2015. Pie-grièche écorcheur *Lanius collurio*, In: Issa, N. & Muller, Y. (eds.) (2015). Atlas des oiseaux de France métropolitaine. Nidification et présence hivernale. LPO / SEOF / MNHN. Delachaux et Niestlé, Paris.

Couronné, H.-C., Noël, O., Chabot, E., & David, J., 2017. Recensement de la Pie-grièche écorcheur dans les marais de Redon, 22pp.

Cramer, W., & Prentice, I. C., 1988. Simulation of regional soil moisture deficits on a European scale. Norsk Geografisk Tidsskrift 42: 149-151.

Daviaud, E., Depré, C., Lartigau, C., Mercier, F., Neau, D. & Besnard, A., 2023. Estimation de la population de Pie-grièche écorcheur *Lanius collurio* de Poitou-Charentes. Ornithos 30: 312-325.

De Broyer, A. & Paquet, J.-Y., 2020. Suivi de la population de Pie-grièches écorcheurs *Lanius collurio* dans les sites Natura 2000 du LIFE Prairies Bocagères : évolution de la population en lien avec les travaux de restaurations - Rapport final 2020 pour le LIFE Prairies bocagères. Natagora, Rapport du Département Études 2020/02.

Deffandre, M., 2009. Pie-grièche écorcheur *Lanius collurio*, In: Debout, G., 2009. Nouvel atlas des oiseaux nicheurs de Normandie (2003-2005). Gonm, 448pp.

Diehl, B & Myrcha, A., 1973. Bioenergetics of nestling Red-backed Shrikes. Condor 75 : 259-264.

European Environment Agency 2021. https://www.eionet.europa.eu/etcs/etc-bd/activities/reporting/article-12

Fornasari, L. & Massa, R., 2000. Habitat or climate? Influences of environmental factors on the breeding success of the Red-backed Shrike (*Lanius collurio*). Ring 22: 147–156.

Fornasari, Kurlavicius & Massa In Hagemeijer W. & Blair, M. (eds.), 1997. The EBCC Atlas of European Breeding Birds: Their Distribution and Abundance. T. & A.D. Poyser. 903pp.

Goławski, A., 2006. Impact of weather on partial loss of nestlings in the Red-backed Shrike *Lanius collurio* in eastern Poland. Acta Ornith. 41: 15-20.

Groscola, R., 2014. La Pie-grièche écorcheur *Lanius collurio* dans la vallée de Villé (Bas-Rhin) en 2014 : densité, répartition, rapport à l'homme. Ciconia 38: 62-72.

Groscola, R. 2015. Second recensement de la Pie-grièche écorcheur *Lanius collurio* dans la vallée de Villé (Bas-Rhin). Ciconia 39: 15-23.

Groscola, R., 2016. Impact des conditions climatiques printanières sur la reproduction de la Pie-grièche écorcheur dans la vallée de Villé. Communication. Colloque d'ornithologie, Montier en Der, december 2016.

Hornman, M., Nijssen, M., Geertsma, M., Kuper, J. & Esselink, H., 1998. Temporal effects on diet composition in nestling Red-backed Shrike (*Lanius collurio*) in Bargerveen, the Netherlands. IBCE Tech. Publ. 7: 83-87.

Hubálek, Z. (2004) An Annotated Checklist of Pathogenic Microorganisms Associated with Migratory Birds. Journal of Wildlife Diseases 40: 639-659.

Huntley, B., Green, R. E., Collingham, Y. C. Willis, S. G., 2007. A Climatic Atlas Of European Breeding Birds. Durham University, The RSPB and Lynx Edicions, Barcelona. 521pp.

Hušek, J. & Adamik, P., 2008. Long-term trends in the timing of breeding and brood size in the Red-backed Shrike *Lanius collurio* in the Czech Republic, 1964-2004. J. Ornithol. 149: 97-103.

Karger, D.N., Dabaghchian, B., Lange, S., Thuiller, W., Zimmerman, N.E. & Graham, C.H. 2020. High resolution climate data for Europe. EnviDat (https://doi.org/10.16904/envidat.150).

Keller, V., Herrando, S., Voříšek, P., Franch, M., Kipson, M., Milanesi, P., Martí, D., Anton, M., Klvaňová, A., Kalyakin, M.V., Bauer, H.-G. & Foppen, R.P.B. (eds.), 2020. European Breeding Bird Atlas 2: Distribution, Abundance and Change. European Bird Census Council & Lynx Edicions, Barcelona. 967pp.

Lefranc, N., 1979. Contribution à l'écologie de la Pie-grièche écorcheur *Lanius collurio* L. dans les Vosges moyennes. L'Oiseau et R.F.O. 49: 245-298.

Lefranc, N., 2017. Histoire récente, status actuel et tendances évolutives de Pies-Grièches *Lanius sp.* Dans le Grand Est. Ciconia 41:12-26.

Lefranc, N. 2022. Shrikes of the World. Helm, London.

Lehmann, U. & Sommersberg, C.H., 1980. Activity patterns of the common vole, *Microtus arvalis* – Automatic recording of behaviour in an enclosure. Oecologia, 47: 61-75.

Lippens, L. & Wille, H., 1972. Atlas van de vogels in België en West-Europa. Lannoo, 833pp.

Maes, P., Meeus, H. & H. Voet, 1985. Broedvogels in Vlaanderen, 1980-1982. Wielewaal 51:185- 202.

Metzmacher M. & Van Nieuwenhuyse, D., 2012. Dynamique de population de la Pie-grièche écorcheur (*Lanius collurio*) dans le sud-est de la Belgique : modélisation de l'influence du climat. Rev. Écol. (Terre Vie) 67: 353-374.

Molina, B., Nebreda, A. & Del Moral, J. C., 2021. III Atlas de las Aves en época de reproducción en España. SEO/BirdLife. Madrid.

Mottiaux S. 2003. Evaluation ex post des effets aux niveaux agronomique, écologique et paysager d'un remembrement: le cas du remembrement de Couvreux. In Faculté universitaire des sciences agronomiques 85. Gembloux: University of Liège.

Mourgaud, G. & Logeais, J.-M., 2012. Évolution récente de la population angevine de Pies-grièches écorcheurs *Lanius collurio*. Crex 12: 53-58.

Müller, Y., 1998. La Pie-grièche écorcheur (*Lanius collurio*), Oiseau de l'année 1998 en Alsace. Bilan de l'enquête. Ciconia 22: 81-98.

Müller, M., Pasinelli, G., Schiegg , K., Spaar, R & Jenni, L., 2005. Ecological and social effects on reproduction and local recruitment in the Red-backed Shrike. Oecologia 143: 37-50.

Müller, Y., 2015. Bilan de dix années de suivi des indicateurs de la biodiversité en Alsace. Les effectifs de Pie-grièche écorcheur *Lanius collurio*. Ciconia 39 : 96-101.

Muller, Y., 2016. La pie-grièche écorcheur, oiseau de l'année 2015 : bilan de l'enquête. LPO Alsace 55: 4.

Müller, Y. & Groscolas, R., 2015.- La Pie-grièche écorcheur, oiseau de l'année 2015 en Alsace. Bilan de l'enquête avec un zoom sur la vallée de Villé. Communication, Colloque d'ornithologie, Sarrebourg, décembre 2015.

Nesvadbova, J., 1992. Impact of a cloud-burst on a population of *Microtus arvalis* (Pall.). Folia Zool. 41: 289-298.

Nijs, G., 2020. Het landschap als legpuzzel: onderzoek naar de ecologie van de Grauwe Klauwier in Vlaams-Brabant. Natuur.oriolus 86:127-139.

Nijssen, M., 2024. Dertig jaar Stichting Bargerveen, hoe gaat het met de Grauwe Klauwier? https://www.naturetoday.com/intl/nl/nature-reports/message/?msg=31749

Olsson V. 1995. The Red-backed Shrike *Lanius collurio* in southern Sweden: breeding biology. Ornis Svecica 5: 101-110.

Robert, M., 2020. Suivi de population de la Pie-grièche écorcheur *Lanius collurio* en périphérie de la baie de Somme (80, Somme). Avocette 45: 11-23.

Roché, J. E., Muller, Y. & Siblet, J-P., 2013. Une méthode simple pour estimer les populations d'oiseaux communs nicheurs en France. Alauda 81: 241-268.

Roilo, S., Spake, R., Bullock, J.M. & Cord, A.F., 2024. A cross-regional analysis of red-backed shrike responses to agri-environmental schemes in Europe. Environ. Res. Lett. 19: 034004.

Sæther, B.-E., Sutherland, W.J. & Engen, S., 2004. Climate influences on a population dynamics. Adv. Ecol. Res. 35: 185-209.

Sapolsky, R.M., Romero, L.M. & Munck, A.U., 2000. How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative actions. Endocrine Reviews 21: 55-89.

Schabenberger, O. 2005. Introducing the GLIMMIX Procedure for Generalized Linear Mixed Models. SAS Institute Inc.

Schaub, M. & Abadi, F., 2011. Integrated population models: A novel analysis framework for deeper insights into population dynamics. J. Ornithol. 152: 227–237.

Schaub, M., Jakober, H. & Stauber, W. 2011. Demographic response to environmental variation in breeding, stopover and non-breeding areas in a migratory passerine. Oecologia 167: 445-459.

Schaub, M., Jakober, H. & Stauber, W., 2013. Strong contribution of immigration to local population regulation: evidence from a migratory passerine. Ecology 94: 1828–1838.

Søgaard Jørgensen, P., Tøttrup, A. P., Rahbek, C. & Geertsma, M., 2013. Effects of summer weather on reproductive success of the Red-backed Shrike (*Lanius collurio*), Bird Study 60: 1-10.

Takács, V., Kuzniak, S. & Tryjanowski, P., 2004. Predictions of changes in population size of the Red-backed Shrike (*Lanius collurio*) in Poland: population viability analysis. Biol. Lett. 41: 103-111.

Tellería, J. L. (2018). Distribution of the Red-backed Shrike *Lanius collurio* at its western range boundary: patterns and conservation prospects. Ardeola 65: 221-233.

Titeux N., D. van der Elst & D. Van Nieuwenhuyse 2010. Pie-grièche écorcheur, *Lanius collurio*. In: Atlas des Oiseaux Nicheurs de Wallonie 2001-2007 (Eds Jacob J.-P., Dehem C., Burnel A., Dambiermont J.-L., Fasol M., Kinet T., van der Elst D. & Paquet J.-Y.), pp. 396-397. Série Faune-Flore-Habitats, n°5. Aves & Région wallonne, Gembloux, Belgium, 524pp.

Titeux, N., Dufrene, M., Radoux, J., Hirzel, A.H. & Defourny, P., 2007. Fitness-related parameters improve presence-only distribution modelling for conservation practice: the case of the Red-backed Shrike. Biol. Conserv. 138: 207-223.

Titeux N. 2006. Modelling species distribution when habitat occupancy departs from suitability-Application to birds in a landscape context. In Université catholique de Louvain, 256pp.

Tøttrup, A. P.,Klaassen, R. H. G.. Kristensen, M. W., Strandberg, R., Vardanis, Y., Lindström, A., Rahbek, C., Alerstam, T. & K. Thorup, K., 2012. Drought in Africa caused delayed arrival of European songbirds. Science 338: 1307.

Tryjanowski, P., Kuzniak, S. & Diehl, B., 2000. Does breeding performance of Red-backed Shrike *Lanius collurio* depend on nest site selection? Ornis Fenn. 77: 134–141.

UICN France, MNHN, LPO, SEOF & ONCFS., 2016. La Liste rouge des espèces menacées en France - Chapitre Oiseaux de France métropolitaine. Paris, France.

Van den Burg, A., Nijssen, M., Geertsma, M., Waasdorp, S. & Van Nieuwenhuyse, D., 2011. De grauwe klauwier — ambassadeur voor natuurherstel. KNNV Uitgeverij.

Van der Elst, D. & Vieuxtemps, D. 2007. Avifaune du Camp militaire de Marche-en-Famenne : 1981-2007. Aves 44 : 225-238.

Van Nieuwenhuyse, D. & De Middeleer, L., 2016. Effect van ruilverkaveling op populatie Grauwe Klauwier in de Gaume (1983-2015). Natuur.oriolus 82: 37-41.

Van Nieuwenhuyse, D. & De Middeleer, L., 2017. Geclusterde verspreiding van Grauwe Klauwier in de Gaume (Lx). Natuur.oriolus 83: 83-91.

Van Nieuwenhuyse, D. & De Middeleer, L., 2017. Aankomstpatronen en specifieke gedragingen van de Grauwe Klauwier in de Gaume (Lx). Natuur.oriolus I 83:123-131.

Vermeersch, G, Anselin, A, Devos, K, Herremans, M, Stevens, J, Gabriëls, J & Van der Krieken, B., 2004. Atlas van de Vlaamse broedvogels: 2000-2002. Mededeling van het Instituut voor Natuurbehoud, vol. 23, Instituut voor Natuurbehoud.

Williams, R.S., Marbert, B. & Hanson, P., 2008. Precipitation alteration in a hardwood forest affects ground dwelling carabid beetle community composition. Ecological Society of America Annual Meeting.

European Journal of Ecology, 2024, 93-101

LONG-TERM RESEARCH REVEALS EFFECTS OF PEAT MOOR REGENERATION ON A CORE POPULATION OF RED-BACKED SHRIKE *LANIUS COLLURIO*

Marijn Nijssen[1,2], Marten Geertsma[1], Jan Kuper[1,2], Arnold van den Burg[3],
Gert-Jan van Duinen[1,2], Remco Versluijs[1], Stef Waasdorp[3]

[1] *Stichting Bargerveen, Toernooiveld 1, 6525 ED Nijmegen, The Netherlands*
[2] *Radboud Institute for Biological and Environmental Sciences, Department of Ecology, PO Box 9010, 6500 GL Nijmegen, The Netherlands*
[3] *Stichting Zoological Museum Netherlands, Onderlangs 17, 6731 BK Otterlo, The Netherlands*

Corresponding author: Marijn Nijssen (M.Nijssen@science.ru.nl, ++31-647280775)

Abstract.

This study investigates the impact of peat moor restoration on the population dynamics of a core population of the Red-backed Shrike (Lanius collurio) in the Bargerveen nature reserve, The Netherlands. The restoration of raised bogs, initiated in the 1970s and 1980s, aimed to rehydrate desiccated peatlands, enhancing habitat heterogeneity and prey availability for the species. Through a combination of long-term monitoring (1993-2023) of breeding pairs, nest site location, and diet composition, this research examines how restoration measures influenced the distribution and population trends of Red-backed Shrikes. The results show a significant increase in population size, particularly after 2017 with fluctuations in water levels and changes in prey availability as key drivers of the population trend. During raised bog restoration the birds abandon the central part of the peat area and colonize the buffer zones. Nesting opportunities have increased due to the development of thorny shrub vegetation and adapted management practices ensuring that habitat restoration does not reduce nesting sites. Furthermore, climatic factors, particularly warm and dry weather, have positively influenced reproductive success. The findings support the hypothesis that large-scale, landscape-level restoration of peat bogs, including the surrounding lagg-zones and buffer areas, is essential for sustaining Red-backed Shrike populations. The study highlights the importance of integrated habitat management and the influence of external factors, such as climate change, on species recovery.

Keywords: *Red-backed Shrike; Peat moor restoration; Habitat heterogeneity; Population dynamics; Buffer zones; Climate change; Landscape-scale conservation.*

*This article is dedicated to Hans Esselink (1954-2008)

Hans Esselink (1954-2008) ringing Red-backed shrike nestlings in 1992 in the Bargerveen Nature Reserve.

1. Introduction

The Red-backed Shrike (*Lanius collurio*, Linnaeus, 1758) was once a common breeding bird in the Netherlands, with an estimated population of 10,000 breeding pairs at the turn of the 20th century. However, habitat destruction due to changes in land use caused a sharp nationwide population decline, with only 200-280 breeding pairs remaining between 1985 and 1990 (Hustings & Bekhuis, 1993). The Bargerveen nature reserve, a remnant peat moor near the German border, was one of the few places that preserved a small population of Red-backed Shrikes. In clear contrast to almost every other population in North-West Europe, this population began to increase from the late 1980s, coinciding with the implementation of nature restoration measures. It eventually became the national core population for the species. This raised the question of whether peat moor regeneration could save the Red-backed Shrike in the Netherlands (Esselink et al., 1995).

The Bargerveen shrike population has been studied in detail since 1993, focusing on changes in population size, nesting and breeding success, reproduction and recruitment, diet composition, and prey availability. Aspects of the development and breeding ecology of the Bargerveen population have been described in several publications (e.g., Hornman et al., 1998; Geertsma et al., 2000; Hemerik et al., 2015). From the outset of this study, it was hypothesized that restoration measures aimed at regenerating peat moor habitat would reduce habitat suitability and cause a population decline, as living raised bog itself is not a suitable habitat for Red-backed Shrikes. Targeted management and the development of a peripheral lagg- and transition zone between the restored raised bog core and the surrounding agricultural and urban areas would be necessary to supplement suitable habitat in a (semi-) natural landscape setting (Esselink et al., 1994 and 1995).

This article describes the development of the core Red-backed Shrike population between 1993 and 2023, in relation to changes in landscape structure and management, and concludes with the overall ecological lessons learned from this long-term research project.

2. Research Area

The Bargerveen peat moor (Fig. 1) is a nature reserve under the European Natura 2000 legislation, located in the province of Drenthe, The Netherlands (52°40′40″N, 7°802′08″E), near the German border. Managed by the State Forestry Service, it is the largest remnant of the former Bourtanger Moor, a raised bog system that once spanned 1600 to 3000 km². Large-scale peat harvesting continued until the 1970s, with extraction ceasing completely only in 1992. The remaining unexcavated peat moor was secured in 1968, followed by the acquisition and protection of surrounding excavated areas, expanding the protected area to 2083 ha in 1992 (the official Natura 2000 area) and approximately 3000 ha by 2023, including buffer zones.

Figure 1. Topographic map of the study area, Bargerveen peat moor reserve, including buffer zones (red-hatched areas).

Habitat changes in the Bargerveen area in relation to management

To restore a functioning raised bog ecosystem, a range of small and large-scale measures have been implemented in the core area of Bargerveen and its surrounding buffer zones. These efforts aim to retain rainwater, stabilize groundwater levels, and reduce evaporation and shading from tall grasses, shrubs, and trees, thereby promoting conditions for the growth of peat mosses (*Sphagnum* spp.). Starting in the 1970s, a small network of low dikes was constructed around the intact peat bog core, followed by larger dikes built around excavated plots in the 1980s and 1990s. Over time, the Bargerveen transitioned from a drained and excavated, mineralizing raised bog remnant into a varied landscape, featuring small regenerating raised bog areas, wet and dry heathland, mesotrophic grasslands and meadows, and large open water areas. Between 1997 and 1999, a central drainage canal used for peat transport was filled, and a concrete road was removed from the area. The creation of buffer zones with large water basins surrounding the Natura 2000 area further prevented water seepage and stabilized groundwater levels throughout the entire region. As a result, groundwater levels rose by several decimeters (Fig. 2).

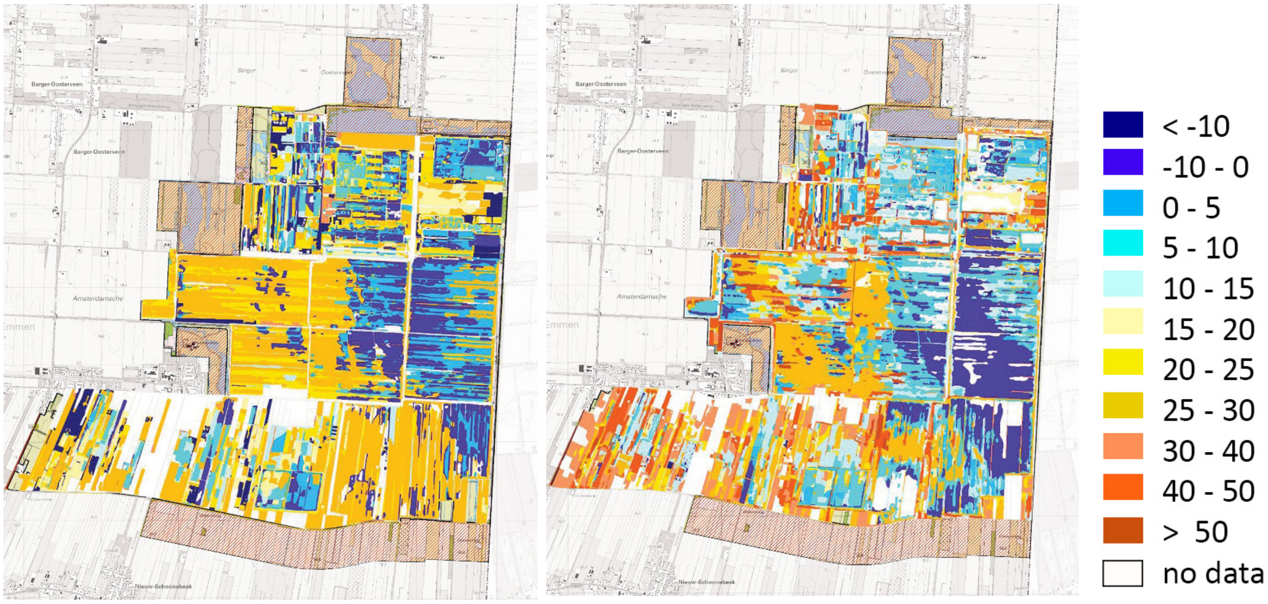


Figure 2. Representation of the area's hydrology (water level relative to ground level, in cm) in 1997 (left) and 2014 (right), extrapolated from vegetation surveys. Note that the decrease in groundwater levels in the central part of the area does not indicate a drop in groundwater but an increase in peat moss development in open water areas. Calculations were made only for the Natura 2000 area and do not include the surrounding buffer zones.

Small trees and shrubs, particularly Birches (*Betula* spp.) and Willows (*Salix* spp.), which had colonized significant areas of the dry, excavated peat, died when water tables were raised. At the same time, sheep and cattle grazing were introduced to counteract the encroachment of Purple Moor grass (*Molinia caerulea*), and shrubs and low trees were removed mechanically. As a result, the central part of Bargerveen transformed into a very open and wet landscape between the late 1990s and 2015, while the surrounding buffer zones had not yet been developed. The last large-scale measures were taken between 2015 and 2018, with the raising of several parts of the larger dike system and the expansion of the buffer zones in the southern part of the area. In addition to the construction of several large water basins, many parts of these buffer zones were converted from arable farming to extensive grasslands, thorny shrubs, and hedges with Blackthorn (*Prunus spinosa*) and Common Hawthorn (*Crataegus monogyna*), as well as encroachment by Blackberry (*Rubus* spp.), providing suitable nesting sites for shrikes and other birds (Fig. 3).

3. Methods

Population trend of Red-backed shrikes

From the 1970s to the present, monitoring of Red-backed Shrikes has been conducted through annual integral censuses using nationally standardized criteria to determine the number of territories (Vergeer et al., 2023). This method is based on occupied territories but does not account for the breeding status of each pair or individual bird (such as solitary males), nor does it correct for movements of pairs or individual birds after disturbances or nest failures. Since 1993, counting the breeding population has been based solely on the number of (potentially) reproducing pairs, including only sites where a) a nest was found, b) a resident pair was observed, or c) young immobile fledglings were detected. Differences between

Figure 3. Typical habitat of the central part of the Bargerveen in 1993 (left), showing large areas of regenerating peat moor vegetation with a mosaic of open water, Cottongrass (*Eriophorum angustifolium*), Birches (*Betula* spp.), and Willows (*Salix* spp.). The surrounding buffer zones in 2021 (right) now feature a mosaic of peat moor (*Sphagnum* mosses), flower-rich grasslands on dike slopes, and mixed shrub areas with Birches, Willows, as well as Blackthorn (*Prunus spinosa*) and Common Hawthorn (*Crataegus monogyna*).

territory estimates and counts of actual breeding pairs are explained by the presence of solitary males and the correction for dispersion of breeding pairs within the season after initial breeding attempts had failed. With these corrected counts, the most reliable estimate of the actual year-by-year size of the breeding population in the Bargerveen area has been made. Data for this began being collected in 1996. For 1993, 1994, and 1995, the population size was retrospectively estimated by using the mean difference between surveys and actual counts during 1996-1999. From 1994 to 2013, a significant portion (approximately 60-80%) of the Bargerveen population was individually marked with color rings, which improved the accuracy of counting separate breeding pairs and allowed for corrections of within-season dispersion of breeding birds. The locations of all breeding pairs' nests have been recorded as accurately as possible in a GIS environment.

Habitat change

Changes in habitat resulting from restoration measures are monitored every 6 to 12 years through full-coverage vegetation surveys, which map the total area and location of specified vegetation types (in accordance with Natura 2000 guidelines) and the distribution of characteristic plant species. Using the GIS toolkit Iteratio (Holtland et al., 2010), the mean highest groundwater level (in spring) for the entire area is calculated based on the mapped vegetation types.

Field surface level territories

Field surface level (meters above sea level) for all breeding pair territories (either nest location when found or the center of breeding pair field observations) was calculated using ArcGIS Pro with digital elevation maps AHN1 (1993-2011), AHN2 (2012-2019), and AHN3 (2020-2023). This calculation was necessary as the construction of dikes during the research period has locally altered field surface levels within the monitoring period 1993-2023.

Diet composition

Diet composition was studied from 1993 to 1996 through visual observations from a shelter at the nest site. To improve the identification of prey items fed to the nestlings, photographs were taken of prey items that could not be identified in the field. The taxon (species, genus, or family) and the size of prey fed to the nestlings were recorded. In total, data on 11,485 prey items from 29 nests were collected. In 2017, diet composition was again studied using automatic Bushnell camera traps. That year, an additional 1,761 prey items from 7 nests were identified.

4. Results

Development of the Red-backed shrike population

The Red-backed Shrike population in the Bargerveen area has been monitored from 1977 to 2023 (Fig. 4). In the 1970s and early 1980s, only a small population of 2-4 territories was present. Numbers increased from the early 1980s to approximately 13-14 territories in 1985-1987, followed by a sharp rise to over 140 territories in 1996-1999. The small population size in the early years and the sudden increase in the following period must be interpreted with caution, as monitoring intensity was relatively low. Red-backed Shrikes can be secretive during the early breeding season, which may lead to an underestimation of the number of pairs. Additionally, solitary birds (mainly males) and dispersing breeding pairs after failed nesting attempts could result in an overestimation of the population. The count of 113-116 actual breeding pairs in 1996-1997 provides a reliable representation of the population size at its peak. After this peak in the late 1990s, the population declined sharply to 37 breeding pairs in 2003, followed by a relatively stable, slightly fluctuating population size of 43 to 60 breeding pairs until 2018. From 2019 onward, the population increased rapidly, reaching 130 breeding pairs in 2023, with only a small dip in 2022.

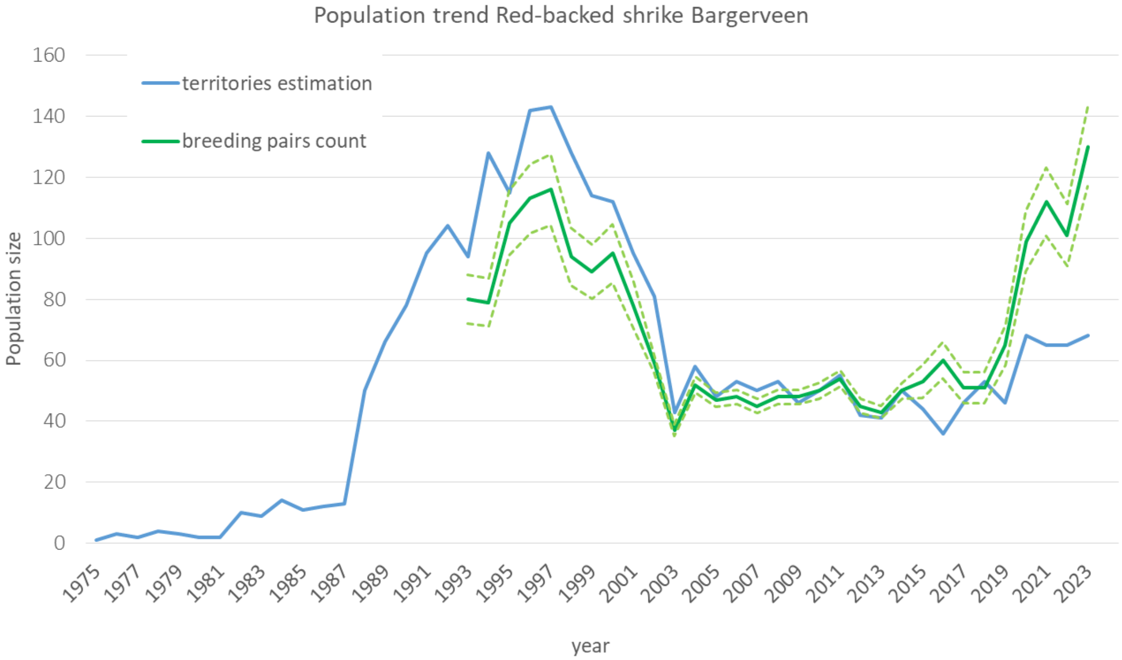


Figure 4. The number of territories (1977-1999) and actual breeding pairs (1993-2023) in the study area, including the protected Natura 2000 area and surrounding buffer zones of Bargerveen, are presented here. The estimation of territories in 1977-1999 is based on standardized monitoring of all individuals and pairs. Counts from 1993 to 2023 are exclusively based on actual breeding pairs (see Materials and Methods). Confidence intervals are estimated retrospectively, taking into account the monitoring intensity in relation to the total population size.

Figure 5. The distribution of breeding pairs of Red-backed Shrikes in the Bargerveen reserve, including the buffer zones surrounding the protected Natura 2000 area, varied over the years. Between 1993 and 1999, there were 624 nest locations. From 2000 to 2016, the number of nest locations increased to 966. However, in the period from 2017 to 2023, the number of nest locations slightly decreased to 770. These figures illustrate the changes in the spatial distribution of breeding pairs over time, with a significant increase in the early 2000s, followed by a small decline in the most recent years.

Distribution of breeding pairs in the Bargerveen

The location of nest sites within the Bargerveen changed significantly during the period from 1993 to 2023 (Fig. 5). During the initial phase (1993-1999), many breeding pairs were present in the northern and southern sections, as well as along the edges of the central section. Areas surrounding the nature reserve were practically unoccupied. In the subsequent period (2000–2016), breeding pairs almost completely disappeared from the edges of the central section, while nesting density increased in many parts of the northern section. Additionally, the first buffer zones and abandoned agricultural areas within the nature reserve were slowly colonized. In the period from 2017 to 2024, nesting sites in the northern section, and to a lesser extent in the southern section, became concentrated along higher dike systems, and the northern buffer zones were increasingly colonized, contributing significantly to the population increase.

This shift in spatial distribution of breeding pairs is also visible in average field surface level of nest locations for Red-backed shrikes in the Bargerveen (Fig. 6). The average level increased by approximately 40 to 60 centimeters (from 18,6 meter to 19.2 meter above sea level) during the period 1993-1999 as breeding pairs moved from the lower central area to the higher fringes and dikes on the edges of the area. Between 2000 and 2012, the average ground surface level of nest locations remained nearly constant. A notable decline is observed from 2013 onwards when breeding pairs choose to nest in the buffer zones, which are situated at lower field surface levels compared to the elevated raised bog system.

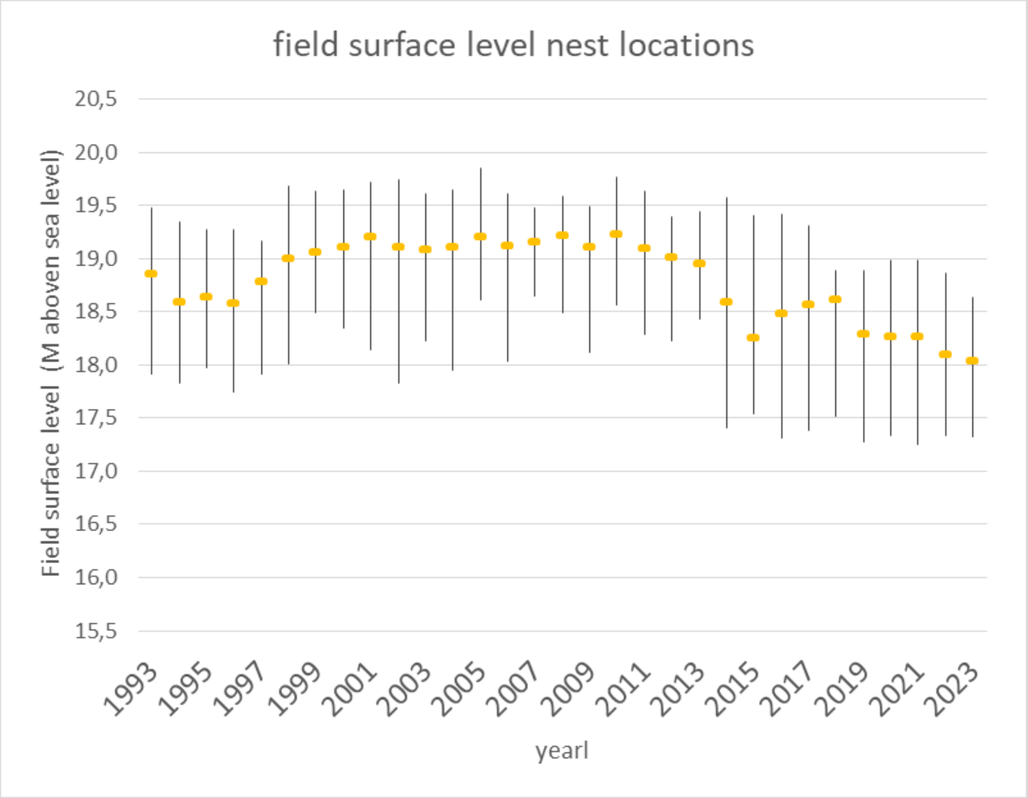


Figure 6. Changes in field height of nesting sites from 1993 to 2023 show a clear trend. Until 2010, the mean field height increased as nesting sites shifted within the raised bog system. This shift was due to the regeneration and development of the central bog area. After 2010, many breeding pairs began to colonize the surrounding buffer zones, which are situated at lower field elevations compared to the raised bog. This shift resulted in a decrease in the average field height of nesting sites as more pairs moved into these lower-lying areas.

Changes in diet composition

The diet of Red-backed Shrike nestlings shifted significantly between 1991-1996 and 2017. During the earlier period, the diet was primarily composed of day-active moths and their caterpillars (*Lepidoptera*; 24.9%), beetles (*Coleoptera*, mainly water beetles Dytiscidae and Scarabid beetles Scarabidae; 15.3%), and dragonflies (*Odonata: Zygoptera* and *Anisoptera*; 12.2%). However, by 2017, the importance of these groups had decreased sharply, while grasshoppers (*Orthoptera*: true grasshoppers *Acrididae* and Bush-crickets *Tettiginiidae*; 29.7%) became a substantial part of the nestling diet.

Some groups remained equally important in both periods, such as bees and wasps (Hymenoptera, mainly Bumblebees *Bombus* spec.; 10.9-13.7%) and spiders (Araneae; 10.3-9.4%). The total number of vertebrates (or parts of them) did not differ significantly between the two periods (11.8% vs. 14.3%), but notable changes were observed within specific species. The frequency of Viviparous lizard (*Zootoca vivipara*) in the diet dropped from 5.3% to 1.3%, while the proportion of pond frogs (Amphibia, Ranidae) increased from 0.4% to 5.5%.

These percentages reflect the number of individual prey items fed to the nestlings. However, when considering the share of total weight and protein content of the prey, vertebrates likely represented a greater proportion of the diet compared to invertebrates (Table 1).

Invertebrates (order)		**1991-96**	*%*	**2017**	*%*	**trend**
Moths & Butterflies	*Lepidoptera*	1585	*15.7*	129	*9.1*	▼
Beetles adults	*Coleoptera*	1546	*15.3*	114	*8.1*	▼
Dragonflies and damselflies adults	*Odonata*	1165	*11.5*	74	*5.2*	▼
Bees, Wasps and ants	*Hymenoptera*	1099	*10.9*	193	*13.7*	
Grasshoppers & bush crickets	*Orthoptera*	1056	*10.4*	419	*29.7*	▲▲
Spiders	*Araneae*	1041	*10.3*	133	*9.4*	
Caterpillars	*Lepidoptera larvae*	929	*9.2*	80	*5.7*	▼
Flies and mosquitos adults	*Diptera*	488	*4.8*	89	*6.3*	
True bugs	*Hemiptera*	230	*2.3*	22	*1.6*	
Beetle larvae	*Coleoptera larvae*	84	*0.8*	7	*0.5*	
Dragonfly larvae	*Odonata larvae*	73	*0.7*	18	*1.3*	
Worms	*Opisthopora*	56	*0.6*			
Woodlice	*Isopoda*	24	*0.2*			
Scorpionflies	*Mecoptera*	17	*0.2*			
Fly and mosquito larvae	*Diptera larvae*	9	*0.1*			
Harvestmen	*Opiliones*	8	*0.1*	1	*0.1*	
Millipeds	*Diplopoda*	5	*0.0*			
Centipeds	*Chilopoda*	2	*0.0*			
Earwigs	*Dermaptera*	2	*0.0*			
Snails	*Stylommatophora*	1	*0.0*	11	*0,8*	
invertebrates unknown		790	*6.9*	248	*14.1*	
vertebrates (class)						
Amphibians	*Amphibia*	43	*0.4*	77	*5.5*	▲▲
Reptiles	*Reptilia*	540	*5.3*	19	*1.3*	▼
Birds	*Aves*	31	*0.3*	10	*0.7*	
Mammals	*Mammalia*	93	*0.9*	14	*1.0*	
Vertebrates unknown		*568*	*4.9*	*103*	*5.8*	

Table 1. The diet composition of nestling Red-backed Shrikes in the Bargerveen area during the period 1991-1996 (11,485 prey items from 29 nests) and in 2017 (1,761 prey items from 7 nests) was based on nest observations. The data are presented as counts of prey items without corrections for prey size or nutritional value.

5. Discussion

In 1995, Esselink et al. posed the question of whether peat moor regeneration could help rescue the Red-backed Shrike population in the Netherlands. The authors hypothesized that this would only be possible if the restoration efforts included the full natural gradient of raised bog systems at a landscape level, encompassing the lagg-zones and transition zones surrounding the living peat moor. As presented in this paper, monitoring of the Red-backed Shrike population from 1993 to 2023 fully supports this hypothesis, based on both the population trend over time and the spatial distribution of breeding birds in relation to the effects of restoration measures taken. Several driving factors can explain the population's response to these measures, both in terms of prey availability and nesting opportunities. These factors interact and can only be partially unraveled.

The primary factor driving population trends and the redistribution of breeding pairs is the fluctuation in water levels within the core of the raised bog reserve (Figure 6). Retaining nutrient-poor rainwater and maintaining a stable water level are essential for the growth of *Sphagnum* mosses, which form living raised bogs. Growing bogs absorb rainwater and create a gradient of nutrient-poor, acidic rainwater transitioning to slightly nutrient-rich, buffered groundwater in the surrounding area.

From the 1970s and 1980s, efforts to retain rainwater in the Bargerveen led to a substantial initial increase in habitat heterogeneity. Formerly excavated, desiccated, and drained peatlands were locally re-wetted, resulting in vegetation succession toward *Sphagnum* bogs, wet heathlands, and willow thickets. More elevated, dry areas retained mesotrophic grasslands and ruderal vegetation on roadside verges and embankments. In the lowest locations, woodland growth died off due to elevated water levels. Although the retained rainwater was nutrient-poor, the upper layer of the desiccated peat had undergone widespread mineralization prior to rewetting, likely enriching the water bodies with nutrients. However, the low pH and isolated location of the water bodies prevented the presence of fish and strongly limited the numbers of amphibians. This led to very high densities of invertebrate aquatic fauna, including dragonflies, water beetles, and aquatic bugs (Heteroptera, mainly *Notonectidae* and *Corixidae*) during the 1990s.

Additionally, the landscape provided a highly suitable habitat for *Viviparous Lizard* and supported a rich floral abundance in wet heathlands with *Erica tetralix* and mesotrophic grasslands, maintaining large populations of bumblebees and diurnal moths. During this period, the recovering raised bog functioned as a large-scale ecotone, offering a high abundance and diversity of prey for Red-backed Shrikes. As water levels further increased, the influence of peat mineralization decreased in relation to acidic, nutrient-poor rainwater, resulting in a decline in aquatic fauna density. Moreover, permanent inundation and the development of *Sphagnum* vegetation reduced the extent of flower-rich heathlands and grasslands, consequently impacting flower-visiting insects.

Only following the acquisition and development of buffer zones did prey availability for Red-backed Shrikes increase again, albeit with significant changes in prey composition. Populations of *Viviparous Lizards* declined markedly, but grasslands, rough grassy verges, and nutrient-rich, buffered waters supported high densities of grasshoppers and pond frogs.

Increasing water levels and removing shrub growth to mitigate evaporation and shading resulted in a decline in nesting opportunities within the central part of the Bargerveen reserve. This affected thornless shrubs, birch (*Betula* spp.) and willow (*Salix* spp.), as well as bramble (*Rubus* spp.). During the 1990s, Red-backed Shrikes often nested in relatively tall, thornless shrubs, which possibly contributed to higher predation rates and lower breeding success during this period. With the development of thorny shrubs such as bramble, blackthorn (*Prunus spinosa*), and hawthorn (*Crataegus monogyna*) at the edges and buffer zones of the raised bog, nesting opportunities significantly increased. Although not specifically studied, it is reasonable to assume that the proportion of successful nests—and thus the average annual reproductive success—has subsequently increased. In recent years, management practices to limit woodland encroachment for peatland recovery have been adjusted to avoid reducing nesting opportunities for shrikes. Rather than cutting birch and other trees at the ground level, stems are partially cut at a height of 50–80 cm and then pushed over (Figure 7). This promotes bramble overgrowth, creating new, secure nesting sites for shrikes and other bird species while effectively limiting birch growth.

Several publications have documented the population development up to 2015. Esselink et al. (1995) initially attributed the significant increase in Red-backed Shrikes entirely to improved habitat quality, particularly the increased prey availability in the Bargerveen. However, subsequent studies on reproductive success and recruitment indicated that this could not explain the growth, and immigration must have played an important role in at least several years during the growth of the population (Geertsma et al., 2000). Hemerik et al. (2014) later estimated that for the observed yearly population growth, approximately 20% of the Red-backed Shrikes breeding in the Bargerveen were immigrants. An untestable hypothesis suggests that during the 1990s and early 21st century, habitat loss in neighboring Germany due to ongoing peat extraction led to the displacement of breeding populations. It is even possible that the Bargerveen may have temporarily functioned as an ecological sink. Research on individually color-ringed shrikes revealed minimal exchange between the Bargerveen population and other Dutch populations (Geertsma et al., 2000). The idea that the Bargerveen acted as a source population for the recovery of Red-backed Shrikes across the Netherlands is likely incorrect. Nonetheless, since the 1990s, the Bargerveen has consistently supported the largest Red-backed Shrike population in the Netherlands. Recent unpublished reproductive data suggest that current population growth is primarily driven by local recruitment.

Figure 7. Nest of Red-backed Shrike on a location with specific management to limit woodland encroachment by partially cutting Birch stems at a height of 50–80 cm and subsequently pushed over, thereby providing nesting sites for shrikes and other bird species while effectively limiting birch growth.

Since 2019, there has been a significant increase in the Red-backed Shrike populations in the Netherlands and other parts of Northwest Europe. In the Netherlands, the estimated population has increased more than sixfold since the 1990s (Sovon, 2024), growing from an estimated 450-550 breeding pairs in 2018 to 1,250-1,550 breeding pairs in 2023 (Boele et al., 2024). In general, the distribution of Red-backed Shrikes is limited by climatic factors (Nijssen, 2020), avoiding very warm and dry conditions in southern Europe, probably facing a mismatch with vegetation greenness on their late arrival from the breeding grounds (Pedersen et al., 2020), as well as high precipitation and low summer temperatures in the north. Søgaard Jørgensen et al. (2013) showed for the Bargerveen and a Danish population that sunny, warm, and dry weather increases reproductive success, with significant effects on the number of fledglings per (successful) pair and lower nestling mortality. Hornman & Nijssen (1996) have demonstrated that weather conditions significantly influence prey availability in the Bargerveen, and Pedersen et al. (2011) found a negative correlation between prey diversity and temperature, indicating that Red-backed Shrikes feed on preferred prey items in warmer summers (low diversity) while being forced to feed on a larger variety of species in colder summers. Moreover, under warm and dry conditions, predation decreases, and fewer subsequent replacement clutches occur (Stichting Bargerveen, unpublished data), leading to a higher average number of fledged young per breeding pair. Additionally, these young fledge earlier in the season, significantly increasing their chances of survival until the next breeding season. In the Bargerveen population, the positive effects of warm and dry weather during the breeding seasons of 2019, 2020, and 2022 almost certainly played an important role, while the population dip in 2022 was likely due to the unfavorable wet weather during the 2021 breeding season.

This research shows that peat moor restoration can indeed facilitate Red-backed Shrike populations, but only when applied on a landscape scale, including the restoration of lagg-zones and buffer zones that belong to a functioning raised bog landscape. Although the role of the Red-backed Shrike as a suitable indicator for the integrity of ecosystems (Esselink et al., 1994) is still valid, it should be considered that an increase in populations of this species can also temporarily occur in disturbed ecosystems or be driven by factors outside the research area, such as climatic changes.

ACKNOWLEDGMENTS

This article is dedicated to Hans Esselink (1954-2008), a pioneer of shrike research in the Netherlands, a highly valued member of the international shrikeologist community, and the initiator of the Bargerveen Foundation. Since 1991, the foundation's staff has been investigating the opportunities and threats facing the Red-backed Shrike in the Netherlands and surrounding countries. Shrike monitoring in the Bargerveen reserve was initiated and, for many years, carried out by Hans van Berkel (1947-2013), with support from the managers of the State Forestry Service, particularly Jans de Vries and Piet Ursem. The research conducted in 2017 was financed by the province of Drenthe, The Netherlands.

REFERENCES

Boele A., J.W. Vergeer, J. van Bruggen, B. Goffin, K. Koffijberg, C. van Oostveen, J. Schoppers and D. Jansen. 2024. Broedvogels in Nederland in 2023. Sovon-rapport 2024/40. Sovon Vogelonderzoek Nederland, Nijmegen.

Esselink, H., M. Geertsma and J. Kuper. 1994. Red-backed Shrike: an indicator for integrity of ecosystems. *Journal für Ornithologie* 135:290-290.

Esselink, H., M. Geertsma, J. Kuper, F. Hustings and H. van Berkel. 1995. Can peat-moor regeneration rescue the Red-backed Shrike in the Netherlands. In: Proc. West. Found. *Vertebr. Zool* 6:287-292.

Geertsma, M., H. van Berkel and H. Esselink. 2000. Are high fitness values sufficient to maintain a Dutch population of the Red-backed Shrike (*Lanius collurio*). *Ring* 22:79-88.

Hemerik, L., M. Geertsma, S. Waasdorp, R. Middelveld, H. van Kleef and C. Klok. 2015. Survival, reproduction, and immigration explain the dynamics of a local Red-backed Shrike population in the Netherlands. *Journal of Ornithology* 156:35-46.

Holtland, W.J., C.J.F. Ter Braak and M.G.C. Schouten. 2010. Iteratio: calculating environmental indicator values for species and relevés. *Applied Vegetation Science*, *13*(3), pp.369-377.

Hornman, M., M. Nijssen, M. Geertsma, J. Kuper and H. Esselink. 1998. Temporal effects on diet composition in nestling red-backed shrike (*Lanius collurio*) in Bargerveen, the Netherlands. Proc. 2nd International Shrike Symposium, Eilat Israel. *IBCE Technical Publication* 7: 83-87.

Hustings, F. and J. Bekhuis. 1993. Grauwe Klauwieren *Lanius collurio* in het Nederland van nu: restanten van een glorieuzer verleden?. *Het Vogeljaar*, 41(1), pp.2-17.

Nijssen, M. 2020. Red-backed shrike (*Lanius collurio*). In: Keller, V., Herrando, S., Voříšek, P., Franch, M., Kipson, M., Milanesi, P., Martí, D., Anton, M., Klvanová, A., Kalyakin, M.V. and Bauer, H.G., 2020. *European breeding bird atlas 2: distribution, abundance and change*. Pp. 538-539.

Pedersen, L., M. Geertsma and A.P. Tottrup. 2012. Prey diversity is affected by climate and differs between age classes in the Red-backed Shrike (*Lanius collurio*). *Ornis Fennica*, 89(2), pp.99-108.

Pedersen, L., A. Onrubia, Y. Vardanis, C. Barboutis, S. Waasdorp, M. van Helvert, M. Geertsma, P. Ekberg, M. Willemoes, R. Strandberg and E. Matsyna. 2020. Remarkably similar migration patterns between different red-backed shrike populations suggest that migration rather than breeding area phenology determines the annual cycle. *Journal of Avian Biology*, 51(10). doi: 10.1111/jav.02475

Søgaard Jørgensen, P., A.P. Tøttrup, C. Rahbek and M. Geertsma. 2013. Effects of summer weather on reproductive success of the Red-backed Shrike (*Lanius collurio*). *Bird Study*, 60(1), pp.1-10.

Sovon 2024. Grauwe klauwier (Red-backed shrike – *Lanius collurio*). https://stats.sovon.nl/stats/soort/15150 (22-11-2024).

Vergeer J.W., A. Boele, J. van Bruggen and C. van Turnhout. 2023. *Handleiding Sovon Broedvogelmonitoring: Broedvogel Monitoring Project en kolonievogels*. Sovon Vogelonderzoek Nederland, Nijmegen.

European Journal of Ecology, 2024, 102-108

THE RED-BACKED SHRIKE (*LANIUS COLLURIO*) IN THE CENTRAL SYSTEM OF THE IBERIAN PENINSULA

Juan Carlos Hidalgo

ALULA Ringing Group. Aranzadi Science Society. (ProyectoLANCOL@gmail.com)

Abstract.

The recent colonization of new breeding territories in Central Spain by the Red-backed Shrike (Lanius collurio) at the end of the 20th century is of significant biogeographical and ecological interest. This geographical expansion is paradoxical given the declining trend of the species across much of its global range. This paper presents findings on the biogeographical patterns and distribution range of the Red-backed Shrike in the Iberian Central system, as well as its habitat preferences, altitudinal shifts, potential distribution, and estimated population during the breeding period in the Community of Madrid (Spain), based on field work conducted between 2018 and 2020. The breeding population in the study area is consistently composed of approximately 500 pairs, with a preference for cool, open areas such as pastures or mosaics of meadows with thorny shrubs, situated above 1,000 m above sea level. These characteristics differentiate this population from those in the Spanish Eurosiberian region. Additionally, the anthropic and socio-economic peculiarities of the study area should be considered when establishing appropriate conservation measures to prevent local extinction in our changing world.

Keywords: *Biogeography, habitat selection, altitudinal shift, distribution, density, population*

INTRODUCTION

In the Iberian Peninsula the Red-backed Shrike (*Lanius collurio*) is present across a wide range of its northern half, from the Pyrenees to the Cantabrian Mountains, Galicia, northern Portugal, and the septentrional Iberian system (Tellería, 2018a; Tellería *et al.*, 2020). In recent years, it has notably expanded its distribution in the Soria province, also colonizing parts of the southern Iberian system in Teruel, Cuenca, Tarragona, and Castellón (Prades *et al.*, 2016). The colonization of the Central system is a more recent phenomenon, as the species was not known to breed there until the end of the 20th century. Currently, it has a population considered regular and apparently stable in Madrid, Segovia, Guadalajara, Avila, Salamanca, and Cáceres (Hidalgo *et al.*, 2020).

The ecological requirements of the Red-backed Shrike during the breeding season link it to the typical habitats of the Eurosiberian region. Its expansion towards the Central system is of significant biogeographical interest, as it highlights the role of mountain massifs as pathways for northern avifauna to penetrate the centre of the Peninsula. This expansion occurs through mountain ranges such as Ayllón, Rincón, Somosierra, and Guadarrama Mountains, which are relatively close to the northern Iberian system and serve as a connection to the Eurosiberian region. This region hosts a variety of typically northern passerines, such as the Common Bullfinch (*Pyrrhula pyrrhula*), Yellowhammer (*Embenza citrinella*), and Marsh Tit (*Poecile palustris*). Additionally, the marked altitudinal gradient of these mountains facilitates the habitat diversification, which benefits numerous bird species (Tellería, 1987). The presence of the Red-backed Shrike in the northern Iberian system has been known since ancient times.

Despite this wide diversity of bird species in mountain habitats, their populations are often sparse, sometimes consisting of only a few individuals. In the case of the Central system, this sparsity is enhanced by the peripheral nature of this Mediterranean mountain range in relation to the Eurosiberian region, further compounded by the geographical isolation of the Iberian Peninsula within the European continent. The distance from centres of abundance results in a decrease in the density and frequency of occurrence of various species towards the edges of their continental distribution, where environmental conditions are likely to be less favourable (Brown, 1984; Sagarin and Gaines, 2002).

Other environmental factors at a more local scale, along with their temporal variations, can also influence species abundance and hinder the recovery of populations after local extinctions. In these peripheral areas, new individuals are expected to arrive only from the edge of their distribution range, where recruitment rates are lower due to the high energetic cost of immigration from the central areas of their range.

Furthermore, understanding the spatiotemporal patterns of occurrences and abundance is more complex for migratory birds, as the ecological requirements of their habitats can change throughout their annual cycle (breeding, wintering, and migration). In this context, the study of habitats used during the breeding season is crucial (Morrison *et al.*, 2021), with habitat selection primarily influenced by factors such as predation risk , parasitism, competition, the availability of suitable nesting substrates, and food abundance (Alerstam, 1993; Newton, 2024).

These three factors- climate, distribution limits, and the peninsular isthmus effect - should be considered together when interpreting population changes in northern

Figure 1. The study area in the Iberian Peninsula.

bird species within the Central system of the Iberian Peninsula. Understanding the environmental parameters that determine the presence and distribution of these species, as well as conducting long-term monitoring to track their spatiotemporal dynamics, is essential for adopting effective conservation measures. This is particularly important in the context of climate change, which could directly or indirectly alter available resources, and consequently impact population abundance, distribution, and the likelihood of local extinctions (Sanz, 2002; Morelli, 2012).

Material and Methods

To assess the connectivity of the Red-backed Shrike population in the Central system (Figure 1) of the Iberian Peninsula with peripherical populations, we hypothesized from an exploratory approach, a progressive colonization of the species from the northern Iberian system. This hypothesis is based on the premise of the existence of potential and homogeneous breeding areas along the Central system, extending to its westernmost limit in Serra da Estrela (Portugal).

We collected 524 occurrences of the Red-backed Shrike in the Central system from 1987 to 2020 during the breeding period (June 1st to August15th) using Citizen Science records (eBird Data Set), ringing records, and bibliographic sources. These data were analysed using GIS, and a table was created to record the time versus the maximum distance (in km) from the breeding site for each year to the closest point of the Central system to the northern Iberian system (Pico Rivilla: 41.30, -3.21). The distances were calculated using the Haversine formula. A regression analysis using a polynomial function was then performed to determine the relationship between these variables.

The study of the Red-backed Shrike's distribution and habitat use in the Community of Madrid (Spain) was conducted over three years: 2018, 2019, and 2020. We designed a sampling protocol using mapping methods to locate and census all known breeding territories from late April to mid-September. A total of 150 visits (35 in 2018, 59 in 2019, and 56 in 2020) were carried out across 30 study areas. The occurrence data collected during fieldwork were processed using GIS to analyze altitudinal distribution and habitat selection.

The geographical distribution and potential population of the species in the Community of Madrid was estimated using a Species Distribution Model (SDM; Maxent v3.4.1). The highest predictive quality, based on the Area Under Curve (AUC) of the model, was achieved using environmental layers such as the hottest quarter temperature, driest quarter precipitation, vegetation structure, vegetation patch surface, and the ecotone index. Optimal habitat was estimated for AUC values greater than 0.9, which was then used to create a potential distribution map for the species.

The potential population was estimated by combining potential distribution, pair density, and a detectability index. This index was obtained by comparing regular censuses and marking all breeding pairs at three breeding sites (Figure 2).

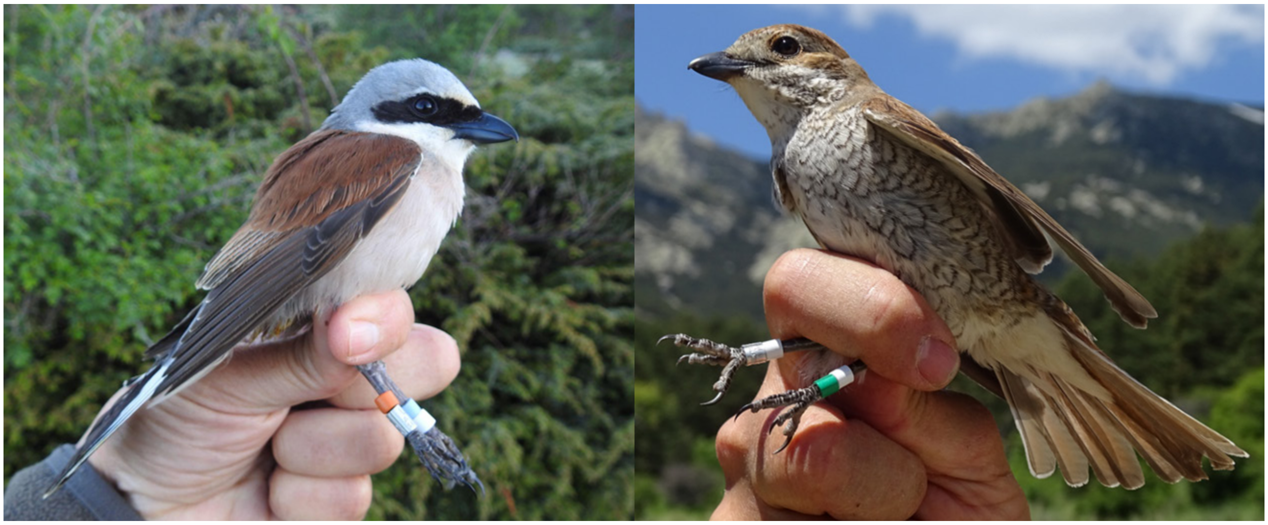


Figure 2. Red-backed Shrike male (left) and female (right) marked with colour rings.

Results

A relationship between the east-to-west distances and the year of observation indicates a westward colonization of the Red-backed Shrike in the Central system, likely originating from the Septentrional Iberian system. The analysis showed a strong positive correlation (r=0.8045, P=<0.0001, n=27 years) between the maximum distance of breeding records from the northern Iberian system each year and the time of records in the Central system (Figure 3). These data suggest that colonization occurred approximately from 1987, the year of the first record, until 2008, when regular sightings were documented throughout the entire Central system (Figure 4; Hidalgo *et al.*, 2020).

The Red-backed Shrike in the central system of the Iberian Peninsula has an altitudinal distribution during the breeding season ranging from 1,040 to 1,722 m a.s.l., with a mean value of 1,368 ± 146 m (n = 289) and a median of 1,356 m with an interquartile range of 217 m. The species' optimal habitat primarily consists of meadows, grasslands, and pastures, featuring small trees and thorny bushes used for nesting and as hunting perches. No breeding territories were found within forests or woods, although they were located in forest ecotones. The presence of the Red-backed Shrike was also not detected in human habitated areas or artificial infrastructures, although this does not appear to be a limiting factor, as breeding territories were identified on the outskirts of small towns.

The SDM obtained (Figure 5) revealed an extremely limited potential distribution range for the Red-backed Shrike in the study area (1,316 km^2), with just 0.7% of this area classified as optimal habitat. The environmental variables that most significantly influenced the SDM were the temperature of the hottest quarter, which had a positive effect for values below 20ºC, followed by vegetation structure, particularly the presence of pastures and bushes. The precipitation of the driest quarter was a limiting factor for values below 53.4 mm.

The census detectability index of 0.71 ± 0.08 was obtained. Across the 30 sites visited, a total of 116 territories occupied by pairs during the reproductive period were identified, with an average density of 4.59 ± 1.54 pairs/10ha. Based on the SDM, the Red-backed Shrike population in the Community of Madrid was estimated at 578 pairs (range 340 - 900; Hidalgo and Baonza 2023).

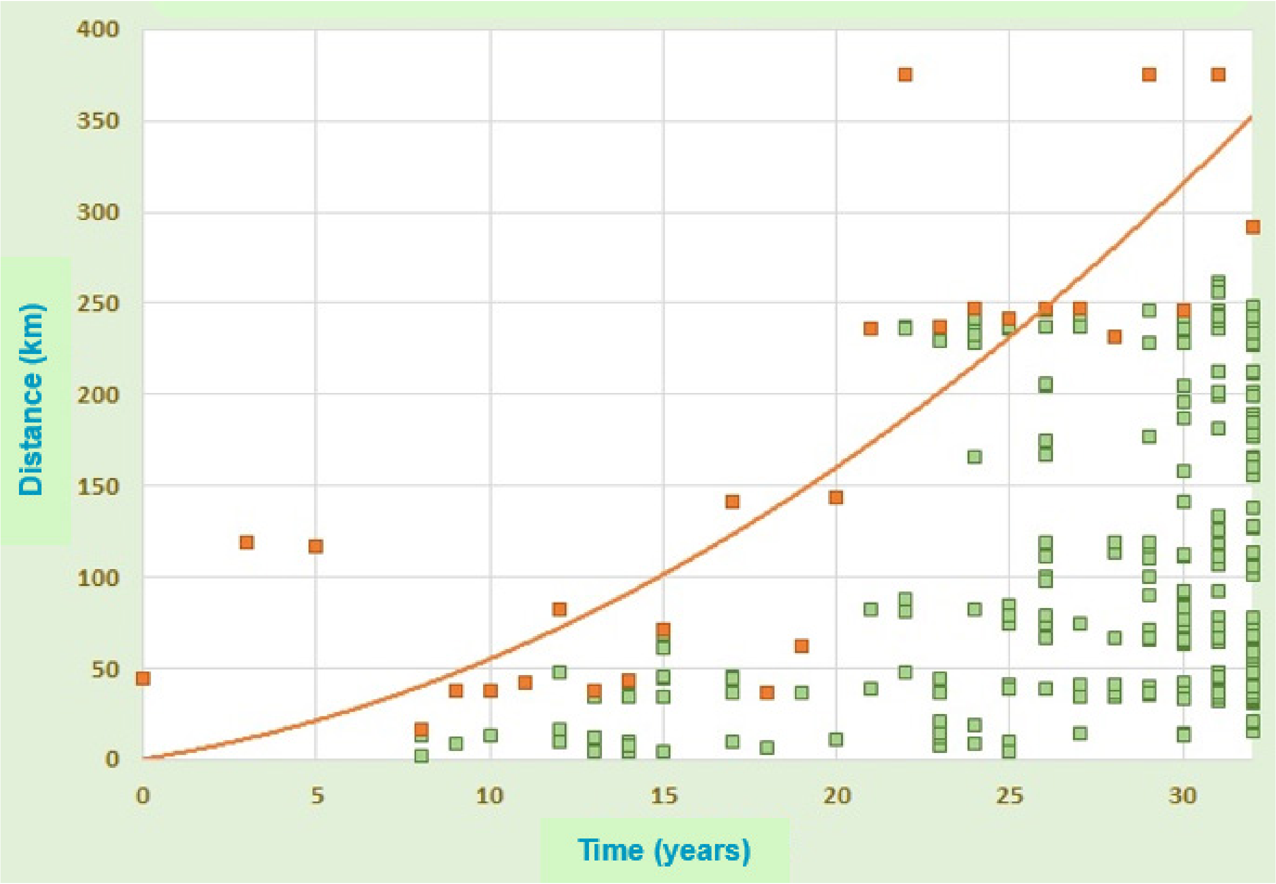


Figure 3. Distance from the septentrional Iberian system to the Red-backed Shrike breeding areas in the Central system of the Iberian Peninsula.

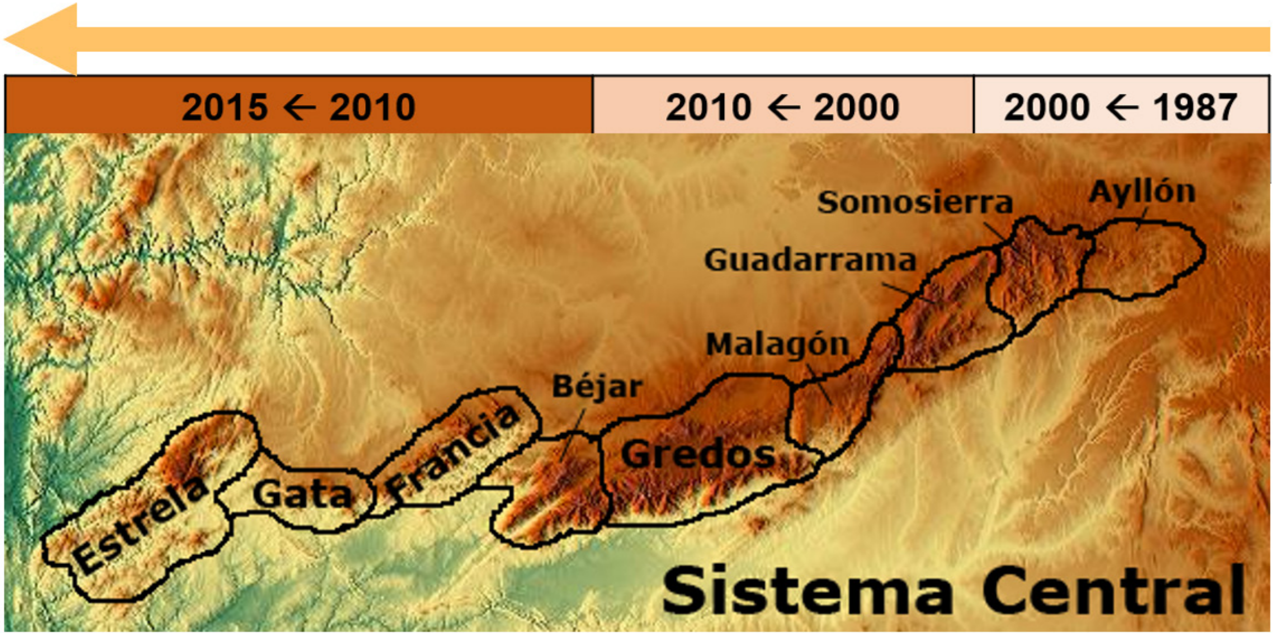


Figure 4. Red-backed Shrike colonization chronology of the Iberian Peninsula Central system.

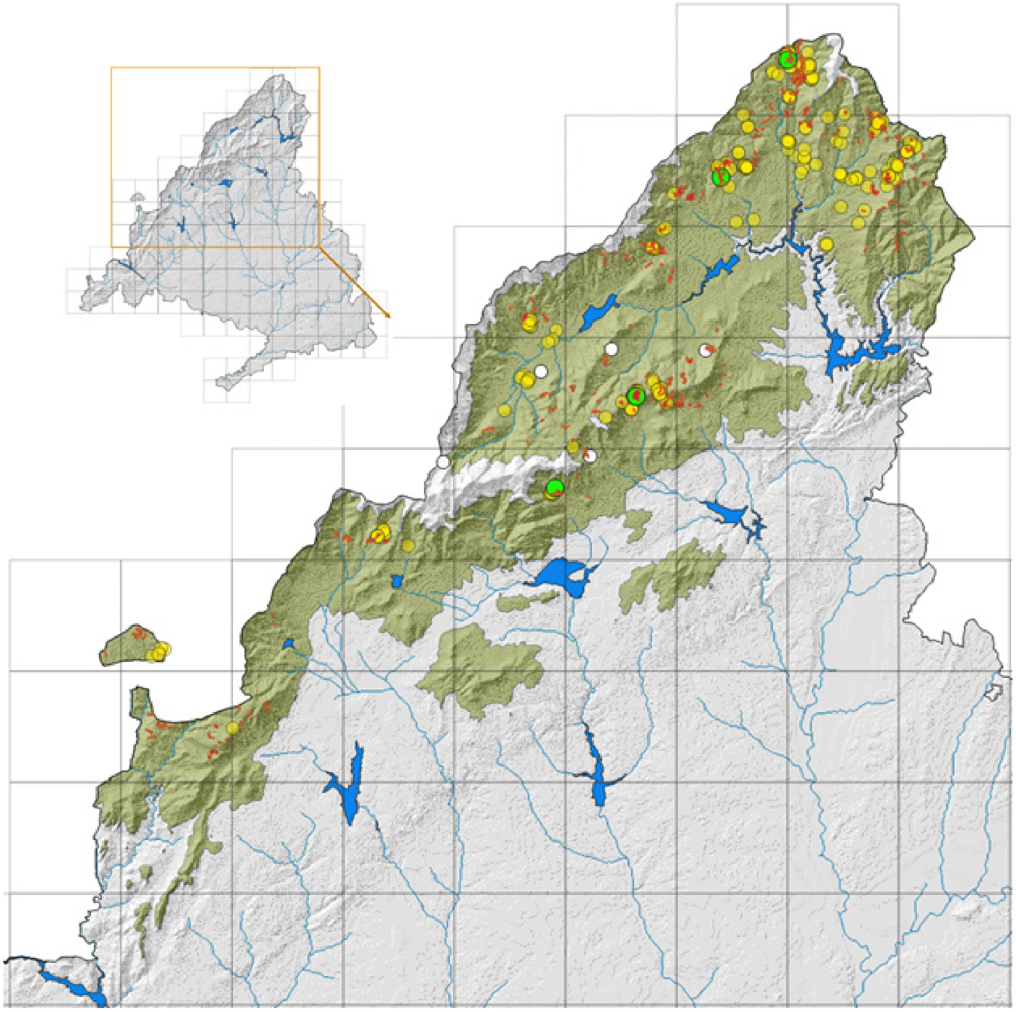


Figure 5. Red-backed Shrike Species Distribution Model in the Community of Madrid, Spain. Areas between 1,000 and 1,800 m a.s.l. (dark green); Potential distribution (red); Circles represent sampling sites –negative presence (white), positive presence (yellow) and positive presence with intensive effort for detectability estimation (light green).

Discussion

In the Community of Madrid, the Red-backed Shrike exhibits a higher altitudinal distribution during the breeding season compared to its range in the Eurosiberian region in the north of the Iberian Peninsula. This distribution is very similar to that observed in other European countries within the Mediterranean region (Inbar, 1995; Moskát and Fuisz, 2002; Tsiakiris *et al.*, 2009; Morelli 2012). The availability of suitable habitat in the study area is quite limited due to the extensive coverage of forest and woods. The species' ecological requirements within the Mediterranean region are met by the altitude and the subtle orographic differences between slopes.

The Red-backed Shrike population in Spain has experienced a significant decline over the past three decades (-54%), particularly in northern Spain and Portugal (Reino *et al.,* 2006; Escandell, 2017; Tellería *et al.*, 2020). However, this decline should not overshadow recent changes in its distribution area. Similar to the relatively recent colonisation of the central Iberian Peninsula by other species with a marked Eurosiberian character, such as the Tree Pipit (*Anthus trivialis*), the Red-backed Shrike has expanded from the septentrional Iberian system into new favourable areas within the Central and southern Iberian Systems, located in the Mediterranean region.

The colonization is partly attributed to the loss of optimal habitat and the accelerated decline of insect abundance across much of its range within the Eurosiberian region (Tryjanowski *et al.*, 2006), including northern Iberian (Tellería, 2018a, 2018b; Tellería *et al.*, 2020). These impacts appear to be linked to the EU's Common Agricultural Policy and its effects on landscape management (Camina and Yosef 2012), such as habitat fragmentation due to land consolidation for intensified agriculture, the loss of traditional extensive grazing that leads to excessive scrubland, and the use of pesticides contributing to arthropod population declines (cf. Yosef and Deyrup 1998).

As with other long-distance migratory species, these threats must be considered throughout the entire annual cycle, which complicates the task of understanding the species' challenges and developing appropriate management measures for conservation at breeding, wintering, and migration sites.

Other global factors, such as climate change, may be altering productivity cycles in breeding areas within the Eurosiberian region, potentially causing a retraction of populations towards mountain ranges, as observed in central Iberia. This trend requires further confirmation in other regions. In the Mediterranean region, climate models predict an increase in temperature that will exacerbate drought and lead to water stress on vegetation and a decline in arthropod productivity (Sanz, 2002; Araújo *et al.*, 2011), which could accelerate the local extinction of certain species populations.

For mountain birds and those within Eurosiberian ecosystems, these effects may push their breeding areas to more northern regions, or higher altitudes (Pearce-Higgins and Martin, 2023), with greater respond for forest clearings or upper the treeline species (Lehikoinen *et al.*, 2019), a pattern already reported for other animals in the Mediterranean region (Wilson, 2005; Flores *et al*. 2018), However, these altitudinal trends can be buffered by other environmental changes at local scale, like the scrubland and woodland encroachment after the land abandonment or the loss of traditional extensive grazing, that are interacting with climate to drive future changes as suggested in long term studies in the Guadarrama Mountains (Tellería, 2019; Caro-Miralles and Gutiérrez, 2023; Tena and Tellería, 2024). Some authors suggest that the combined effects of habitat transformation and climate change will progressively reduce and fragment the breeding populations of Red-backed Shrikes in the Iberian Peninsula, leading to the extinction in regions where recruitment rates do not offset population losses due to the species being at the edge of its Palearctic distribution range (Tellería, 2018a).

The Central system should be regarded as a field-laboratory for observing these changes, with the Red-backed Shrike serving as an excellent bioindicator of the environmental health of mountain agricultural areas. To prevent local extinctions, it is essential to conduct detailed studies of the dynamics of different Iberian populations of this species through long-term monitoring programs. These studies will help to understand the underlying causes and establish appropriate conservation measures.

In conclusion, it is urgent to implement conservation policies for the Red-backed Shrike that include actions to promote traditional extensive livestock farming, prevent land consolidation, and discourage other intensive agricultural practices. Restoration of degraded habitats, controlling excessive scrubland, and installing artificial perches in areas lacking natural ones (Yosef 1993; Van Nieuwenhuyse, 1999) could facilitate the local settlement of Red-backed Shrike populations in valleys and mountain passes with suitable habitats. Raising awareness about the Red-backed Shrike as an indicator of good conservation status in the countryside and other habitats should involve local communities that coexist with the species, encouraging them to conserve and enhance their natural surroundings.

Acknowledgments

We are grateful to the people who assisted us during ringing sessions and other fieldworks, especially to the Álula Ringing Group members. To Lykke Pedersen and Rien van Wijk for sharing their expertise on shrikes. To Anders P. Tøttrup and the Centre for Macroecology, Evolution and Climate at the University of Copenhagen for their interest and project support. To Jose Luis Tellería and Federico Roviralta for their citations and valuable comments to this project. To the Environment, Territorial

Management and Sustainability Department of the Community of Madrid for facilitating the permits for access (Ref: 10/408796.9/19, Ref: 10/428232.9/19 and Ref: 10/028306.9/20) and necessary ringing activities (Ref: 10/137270.9/20; Ringer No. A0365 – Arazadi Science Society).

Bibliography

Alerstam, T., 1993. *Bird Migration*. Cambridge University Press, Cambridge.

Araújo, M. B., Guilhaumon, F., Neto, D. R., Pozo, I., Calmaestra, R., 2011. *Impactos, vulnerabilidad y adaptación al cambio climático de la Biodiversidad Española*. 2. Fauna de vertebrados. Dirección general de Medio Natural y Política Forestal. Ministerio de Medio Ambiente, Medio Rural y Marino. Madrid.

Brown, J., 1984. On the Relationship between Abundance and Distribution of Species. *The American Naturalist* 124:255–279.

Camina A., R. Yosef., 2012. Effect of European Union BSE- related enactments on fledgling Eurasian Griffon (*Gyps fulvus*). *Acta Ornithologica* 47:101-109.

Caro-Miralles, E., Gutiérrez, D., 2023. Butterfly population trends track vegetation encroachment but not climate warming in a Mediterranean mountain. *Biodivers. Conserv*. 32:2017–2035.

Escandell, V., 2017. Programa Sacre. In; SEO/BirdLife. *Programas de Seguimiento de Avifauna y Grupos de Trabajo* 2016: 4-11 SEO/ Birdlife. Madrid.

Flores, O., Seoane, J., Hevia, V., Azcárate, F.M., 2018. Spatial patterns of species richness and nestedness in ant assemblages along an elevational gradient in a Mediterranean mountain range. *PLOS ONE* 13: e0204787.

Hidalgo, J.C., Baonza, E., 2023. Selección de hábitat, distribución y población del alcaudón dorsirrojo (*Lanius collurio*) en la Comunidad de Madrid. *Anuario Ornitológico de Madrid* 2021:21–44.

Hidalgo, J.C., Talbante, C., Baonza, E., Ortega, A.H., 2020. Así fue cómo colonizó el alcaudón dorsirrojo el Sistema Central. *Quercus* 416:16–23.

Inbar, R., 1995. Shrikes nesting on Mount Hermon, Israel. *The Western Foundation of Vertebrate Zoology* 6:215-217.

Lehikoinen, A., Brotons, L., Calladine, J., Campedelli, T., Escandell, V., Flousek, J., Grueneberg, C., Haas, F., Harris, S., Herrando, S., Husby, M., Jiguet, F., Kålås, J. A., Lindstrom A, Lorrillière, R., Molina, B., Pladevall, C., Calvi, G., Sattler, T., Schmid, H., Sirkia, P.M., Teufelbauer, N., Trautmann, S., 2019. Declining population trends of European mountain birds. *Glob. Change Biol*. 25:577-588.

Morelli, F., 2012. Plasticity of Habitat Selection by Red-Backed Shrikes (*Lanius collurio*) breeding in different landscapes. *Wilson J. Ornithol*. 124:51–56.

Morrison, C.A., Butler, S.J., Robinson, R.A., Clark, J.A., Arizaga, J., Aunins, A., Baltà, O., Cepák, J., Chodkiewicz, T., Escandell, V., Foppen, R.P.B., Gregory, R.D., Husby, M., Jiguet, F., Kålås, J.A., Lehikoinen, A., Lindström, Å., Moshøj, C.M., Nagy, K., Nebot, A.L., Piha, M., Reif, J., Sattler, T., Škorpilová, J., Szép, T., Teufelbauer, N., Thorup, K., Van Turnhout, C., Wenninger, T., Gill, J.A., 2021. Covariation in population trends and demography reveals targets for conservation action. *Proc. R. Soc. B*. 288:29-55.

Moskát, C., Fuisz, T. I., 2002. Habitat segregation among the woodchat shrike, *Lanius senator*, the red-backed shrike, *Lanius collurio*, and the masked shrike, *Lanius nubicus*, in NE Greece. *Folia Zoologica* 51:103-111.

Newton, I., 2024. *The migration ecology of birds, Second edition*. ed. Academic Press, an imprint of Elsevier, London.

Pearce-Higgins, J., Martin, K., 2023. Climate change impacts on mountain birds. In *Ecology and conservation of mountain birds. Ecology, Biodiversity and Conservation* (Chamberlain, D., Lehikoinen, A., Martin, K. eds.). Cambridge University Press Pp. 215-259.

Prades, R., Greño, J., Llopis, A., Fabregat, C., 2016. Primers casos comprovats de nidificació d'escorxador (*Lanius collurio*) al País Valencià. *Nemus* 6:177–180.

Reino, L., Beja, P., Heitor, A. C., 2006. Modelling spatial and environmental effects at the edge of the distribution: the red-backed shrike *Lanius collurio* in Northern Portugal. *Div. Distrib*. 12:379-387.

Sagarin, R.D., Gaines, S.D., 2002. The "abundant centre" distribution: to what extent is it a biogeographical rule? *Ecol. Letters* 5:137–147.

Sanz, J.J., 2002. Climate change and birds: Have their ecological consequences already been detected in the mediterranean region? *Ardeola* 49:109–120.

Tellería, J.L., 1987. Biogeografía de la avifauna nidificante en España central. *Ardeola* 34:145-166.

Tellería, J.L., 2018a. Distribution of the Red-Backed Shrike *Lanius collurio* at Its Western Range Boundary: Patterns and Conservation Prospects. *Ardeola* 65:221–232.

Tellería, J. L., 2018b. Old counts suggest the collapse of two Red-backed shrike *Lanius collurio* populations. *Ardeola* 65:283-290.

Tellería, J.L., 2019. Altitudinal shifts in forest birds in a Mediterranean mountain range: causes and conservation prospects. *Bird Conservation International* 30:495-505.

Tellería, J. L., Lizarraga, A., Hernández, A., 2020. Alcaudón dorsirrojo - *Lanius collurio*. In book: López, P., Martín, J., Moreno-Rueda, G. (ed.) *Enciclopedia Virtual de los Vertebrados Españoles*. Museo Nacional de Ciencias Naturales. Madrid.

Tena, E., Tellería, J.L., 2024. Divergent altitudinal distributions of bird and bat species richness in a Mediterranean mountain range: patterns and prospects. Anim. *Biodiv. Conserv*. 47:89-99.

Tsiakiris, R., Stara, K., Pantis, J., 2009. Microhabitat Selection by Three Common Bird Species of Montane Farmlands in Northern Greece. *Environmental Management* 44:874-887.

Tryjanowski, P., Sparks, T. H., Crick, H. Q. P., 2006. Red-backed Shrike *Lanius collurio* nest performance in a declining British population: a comparison with a stable population in Poland. *Ornis Fennica* 83:181-186.

Van Nieuwenhuyse, D., Nollet, F., Evans, A., 1999. The ecology and conservation of the red-backed shrike *Lanius collurio*. *Aves* 36:179-192.

Wilson, R.J., Gutiérrez, D., Gutiérrez, J., Martínez, D., Agudo, R., Monserrat, V.J., 2005. Changes to the elevational limits and extent of species ranges associated with climate change. *Ecol. Letters* 8:1138-1146.

Yosef, R., 1993. Influence of observation posts on territory size in Northern Shrikes. *Wilson Bull.* 105:180-183.

Yosef, R., Deyrup, M., 1998. Effects of fertilizer-induced reduction of invertebrates on reproductive success of Loggerhead Shrikes (*Lanius ludovicianus*). *J. Ornithol*. 139:307-312.

European Journal of Ecology, 2024, 109-115

TEMPORAL CHANGES IN THE DISTRIBUTION AND DENSITY OF THE IBERIAN GREY SHRIKE *LANIUS MERIDIONALIS* IN SOUTHERN FRANCE FROM A SPATIAL ANALYSIS COVERING 1994-2023

Frédéric Labouyrie

f.labouyrie@orange.fr

Abstract.

The Iberian grey shrike, Lanius meridionalis, breeds exclusively in Mediterranean France and on the Iberian Peninsula, where its preferred habitats include a mix of agricultural lands and evergreen oak forests. Despite maintaining a strong presence in certain areas, the species has faced many challenges due to environmental changes, agricultural intensification, and habitat alteration, earning it a place on the IUCN Red List of Threatened Species. This study presents an in-depth spatial analysis of the distribution and density of the Iberian grey shrike Lanius meridionalis in southern France, spanning 30 years from 1994 to 2023. We applied spatial mapping methods and kernel density analysis to examine changes in the spatial distribution of this species. Our results suggest a 47% reduction in its home range since 1994 and fragmentation in the southern part of its distribution area, distinguishing it from its Iberian stronghold.

Keywords: *Iberian Grey Shrike, Observational data, Population density, Spatial distribution, France*

Introduction

The Iberian grey shrike, *Lanius meridionalis*, is a distinct member of the family *Laniidae* and is specific to the diverse open landscapes of the western Mediterranean, including southern France and the Iberian Peninsula. This passerine bird, measuring 24-25 cm and weighing between 48-93 grams, is characterized by its stately shrike shape and relatively long tail, making it conspicuous in its habitat. The species features a distinctive black mask extending from the eyes to the posterior ear coverts, contrasted by a narrow white supercilium. Its plumage features dark grey upperparts, white underparts with a light pink-grey coloration, and a characteristic black tail with white tips on the outer feather peninsula (Hernández, 2020; Lefranc & Worfolk, 2022; Yosef, 2020).

The Iberian Grey Shrike inhabits the Iberian Peninsula and Southern France, thriving in open, sunny lowlands up to altitudes of about 1200 m, adorned with thorny bushes (Lefranc & Worfolk, 2022) (Figure 1). Its preferred habitats include a mix of agricultural lands (e.g., for cereal production, vineyards, orchards, and pastures) and evergreen oak forests, indicating its adaptability and specific ecological requirements. The species' dependence on these habitats underscores the importance of understanding its distribution and density patterns for effective conservation strategies (Hernández, 2020).

Figure 1: Map showing the Iberian grey shrike *Lanius meridionalis* distribution in France and Spain (green: year-round, blue: likely winter presence). Arrows indicate possible winter migration routes (from Lefranc & Worfolk, 2022). In red is the study area.

Lanius meridionalis is primarily an insectivore but also eats small vertebrates. Its foraging strategy often involves impaling prey on thorns or barbed wire, a characteristic behaviour among shrikes. This strategy reflects its unique ecological niche and influences its habitat and prey preferences (Hódar, 2006; Lepley et al., 2004). *Lanius meridionalis* presents an intriguing case study in avian taxonomy and ecology. Historically, it was treated as conspecific with *L. excubitor*, while recent studies have advocated for its recognition as a distinct species based on apparent morphological, behavioural, and ecological differences. Since 1993, in France, the Southern (*Lanius elegans meridionalis)* and Northern Great Grey Shrike (*Lanius excubitor excubitor*) are considered two distinct species with parapatric distributions, i.e., they occupy adjacent but non-overlapping ranges without any known hybridization zone (Isenmann & Bouchet, 1993).

Recent molecular studies have provided critical insights into the taxonomic relationships within the Great Grey Shrike complex (Klassert et al., 2008; Olsson et al., 2010; Poelstra, 2010). The mitochondrial gene tree suggests a non-monophyly of the *Lanius excubitor* complex. Based on morphological, ecological, and geographical data, it challenges the traditional bifurcation into northern (*L. excubitor*) and southern (*L. meridionalis*) species. Furthermore, these studies highlighted the existence of at least six potential species within the complex, including *L. borealis, L. elegans, L. excubitor, L. lahtora, L. meridionalis,* and *L. uncinatus*. However, the authors noted difficulties delineating clear taxonomic boundaries due to the recent divergence and close genetic relationships among these taxa.

The taxonomic recognition of *Lanius meridionalis* as a separate species is not merely a matter of nomenclature but has profound implications for its conservation. With its distribution limited to the western Mediterranean region, understanding its population dynamics, distribution changes, and habitat preferences is vital for effective conservation strategies. Clarifying its status as a separate species underscores the need for targeted conservation efforts and habitat management.

Despite its robust presence in certain areas, the Iberian Grey Shrike has faced challenges due to environmental changes, agricultural intensification, and habitat alteration. Being on the IUCN Red List of Threatened Species, it is classified as vulnerable on a global scale. It breeds exclusively in southern France and the Iberian Peninsula (BirdLife International, 2017; Infante & Hernández, 2018). In Spain, which hosts about 95% of the global population, the species continues to experience a significant decline, with recent annual rates averaging about -5.1% between 1998 and 2019, thus causing a cumulative decrease of 67% over the 21 years (Octavio Infante *pers. com.*; SEO/BirdLife, 2017). In Portugal, population trends are also negative, with a 13 to 40% decrease between 2004 and 2011 (Alonso pers.com; Equipa Atlas, 2022). The national breeding population in France is estimated to be between 550 and 1150 pairs, with a significant decline of 40% between 1993 and 2013 (Hameau et al., 2015).

The primary objective of this study is to examine and characterize changes in the spatial distribution and density of the Iberian Grey Shrike, *Lanius meridionalis,* between 1994 and 2023 in France. It shares no overlap or hybridization zone with its northern counterpart in this region. Our research follows recent taxonomic revisions and seeks to provide updated information on the species' spatial ecology, thereby contributing to conservation efforts and facilitating a better understanding of biodiversity in the Mediterranean region. We employ spatial mapping techniques, kernel density analyses, and other spatial statistical methods to understand how the species distribution and density have evolved.

METHODS

Study Area

The study covers various regions in France, focusing on the Iberian Grey Shrike's habitats in the Mediterranean climate zones, specifically in the Occitania and Provence-Alpes-Côte d'Azur regions. Strictly adhering to the Mediterranean climate, the Iberian Grey Shrike is present in France during the breeding season (approx. 1 March to 31 August) in diverse habitats along the Mediterranean coast. These include agricultural plains of "steppe-like" vineyards with low hedges (brambles, *Rubus sp.)* in the Languedoc region and areas of dry cultivation at supra-Mediterranean altitudes in the Provence region, semi-steppe lands of Crau, and grazed mid-altitude areas (up to 1600m in Causses and Cerdagne). The study also covered karst plateaus with Kermes oak *Quercus coccifera* and regions that experience fires (Hameau et al., 2019). The wide range of landscapes offers comprehensive insights into the species' distribution and density changes and provides a robust 30-year dataset for spatial analysis (Hameau et al., 2015).

Data Collection

Observational data were extracted from the collaborative data portal Faune-France (faune-france.org), an online participatory database containing observational data for a range of taxonomic groups, including birds, mammals, reptiles, amphibians, and insects, compiled by both occasional naturalists and professionals using standardized protocols. The collected data are regularly synthesized into reference works (atlases, red books, species fact sheets, habitat fact sheets) and used in various studies (national action plans, local biodiversity atlases, green and blue infrastructure projects).

We extracted all observations of the Iberian Grey Shrike from 1994 to 2023 from this database, including the spatial coordinates of sightings during the estimated breeding period from 1 March to 31 August each year (N = 20,100 data points).

Data Analysis

We divided our study into four time periods, namely: 1994-2004, roughly corresponding to the pre-internet period, i.e., without widescale public access to high-speed internet and therefore without any online data collection platforms where lay naturalists could report their sightings; 2005-2014, a period roughly coinciding with the advent of high-speed internet for all and a growing involvement of the general public (citizen science); 2015-2019, coinciding with the duration of a French national action plan and associated monitoring protocol for Shrike conser-

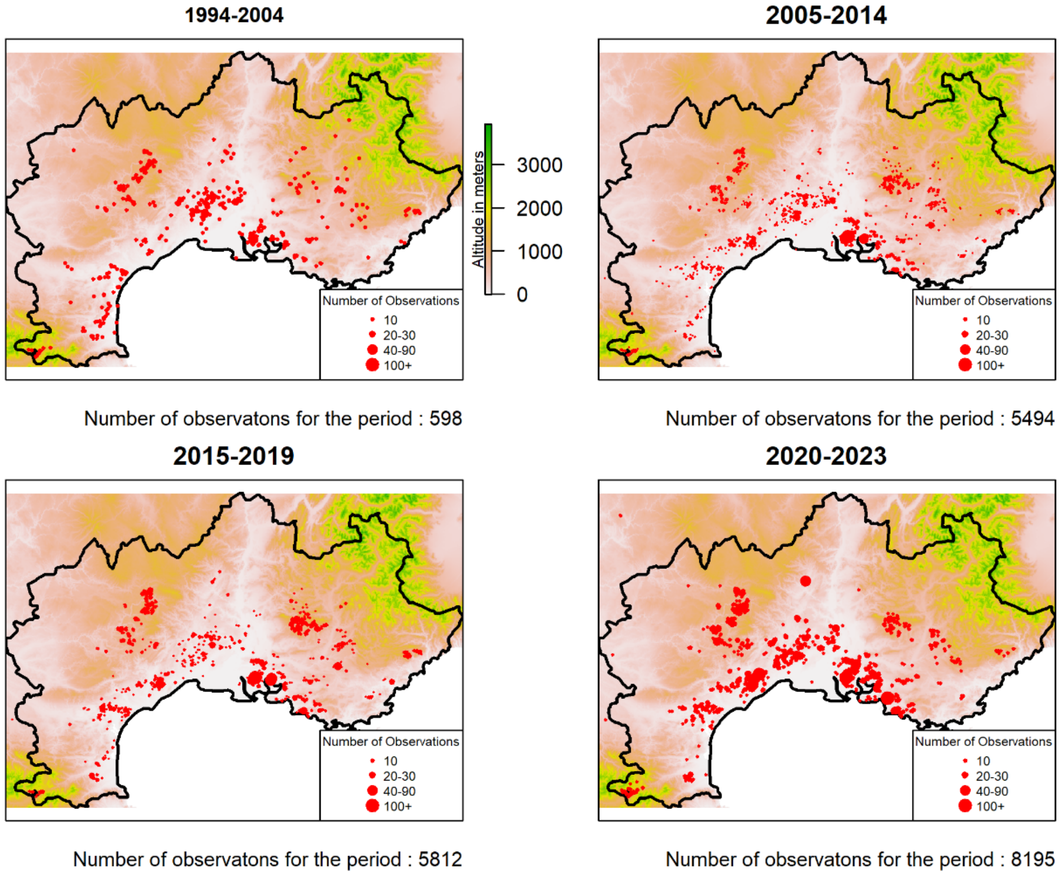


Figure 2: Temporal evolution of the spatial distribution of Iberian grey shrike (*Lanius meridionalis*) sightings during the breeding season in southern France. (Fig. 1 shows the location of the study area in its European context)

vation (Lefranc & Issa, 2013); and finally 2020-2022, the most recent post-action plan period. This division allows us to examine temporal variations in response to broader societal and political changes.

The data analysis involved several statistical and spatial mapping methods, including kernel density estimation (KDE). The spatial coordinates of yearly sightings were binned into spatial grid boxes (grid size: 10x10 km) overlaid onto the habitat map to visually assess temporal variations in their spatial distribution.

We employed KDE to generate smoothed heat maps of Shrike distributions using the *kernelUD* function (v. 0.4.21) from the *adehabitatHR* R package. This process involved creating spatial points and kernel density estimates that were cropped and masked to the study area (Worton, 1989; Seaman & Powell, 1996 .

We also conducted a Density-Based Spatial Clustering of Applications with Noise (DBSCAN) analysis using the *dbscan* R package, which allowed us to detect and visualize clusters based on the density of sighting locations (Ester et al., 1996). This type of analysis highlights the main active areas by filtering out one-off observations, which are considered noise.

Results

Distribution of Sightings

Between 1994 and 2004, there were only a few recorded observations, followed by a 10-fold increase between 2005 to 2014, likely due to increasing public engagement (see Section 2.3), and another marked increase after 2015, possibly due to the implementation of a French national action plan and associated systematic monitoring effort (Figure 2). The number of sightings further increased during the most recent period, 2020-2023, with the yearly average number of sightings nearly doubling compared to the preceding period.

Density of Sightings during the Breeding Season

The heat maps illustrate the spatial and temporal distribution of Shrike sightings during the breeding period (Fig. 3) and changes in sighting density over time. While these maps visualize the frequency of sightings rather than the actual population density and likely include bias due to observer activity (areas more accessible or popular with observers produce more sightings), they do illustrate some shifts in breeding hotspots, also from more coastal to inland areas over the four time periods.

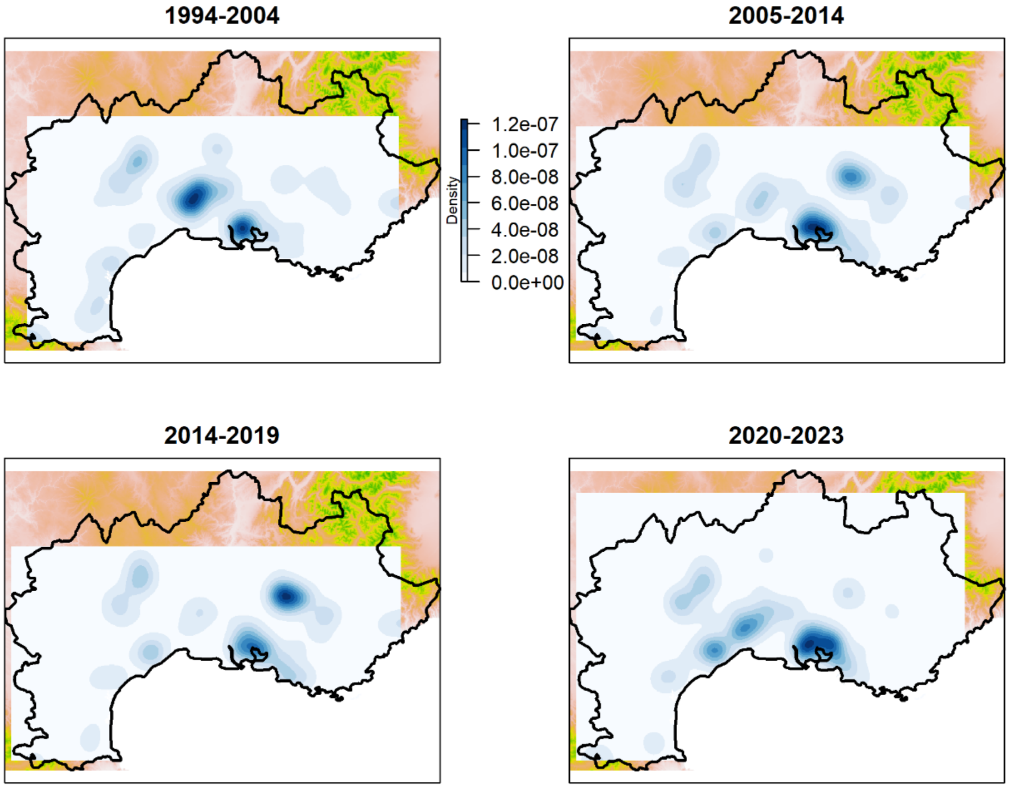


Figure 3: KDE heat maps of the sightings of the Iberian grey shrike (*Lanius meridionalis*) during the breeding season in southern France from 1994 to 2023.

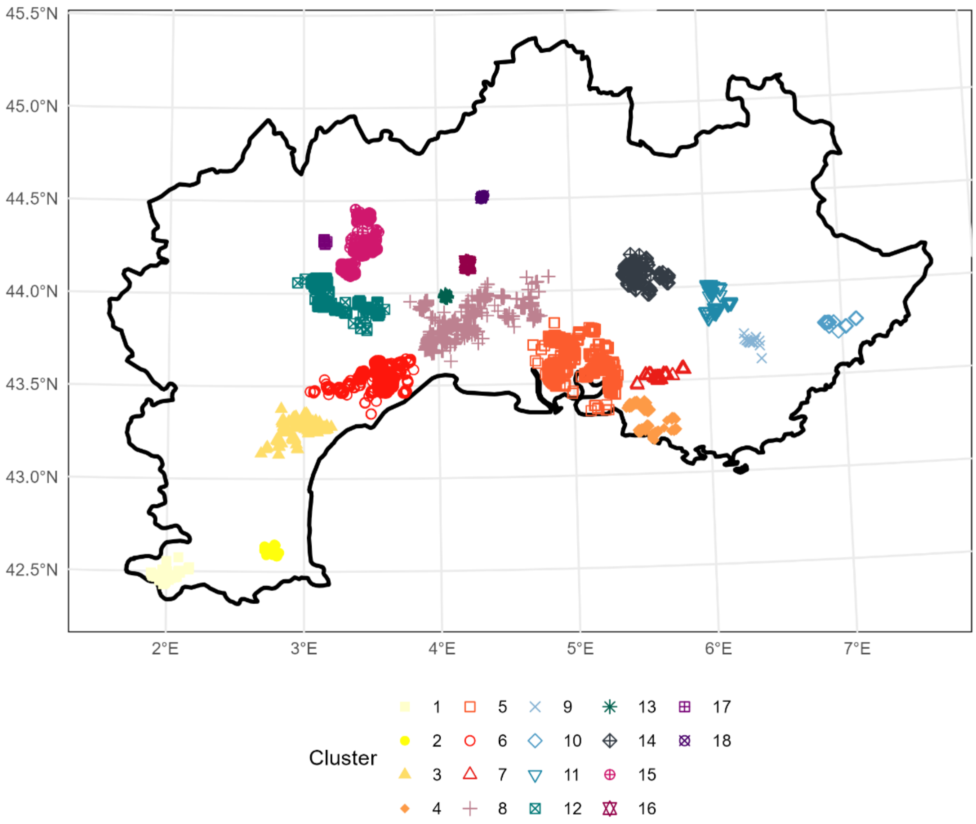


Figure 4: Cluster Analysis of Iberian Grey Shrike Observations in Southern France from 2020 to 2023.

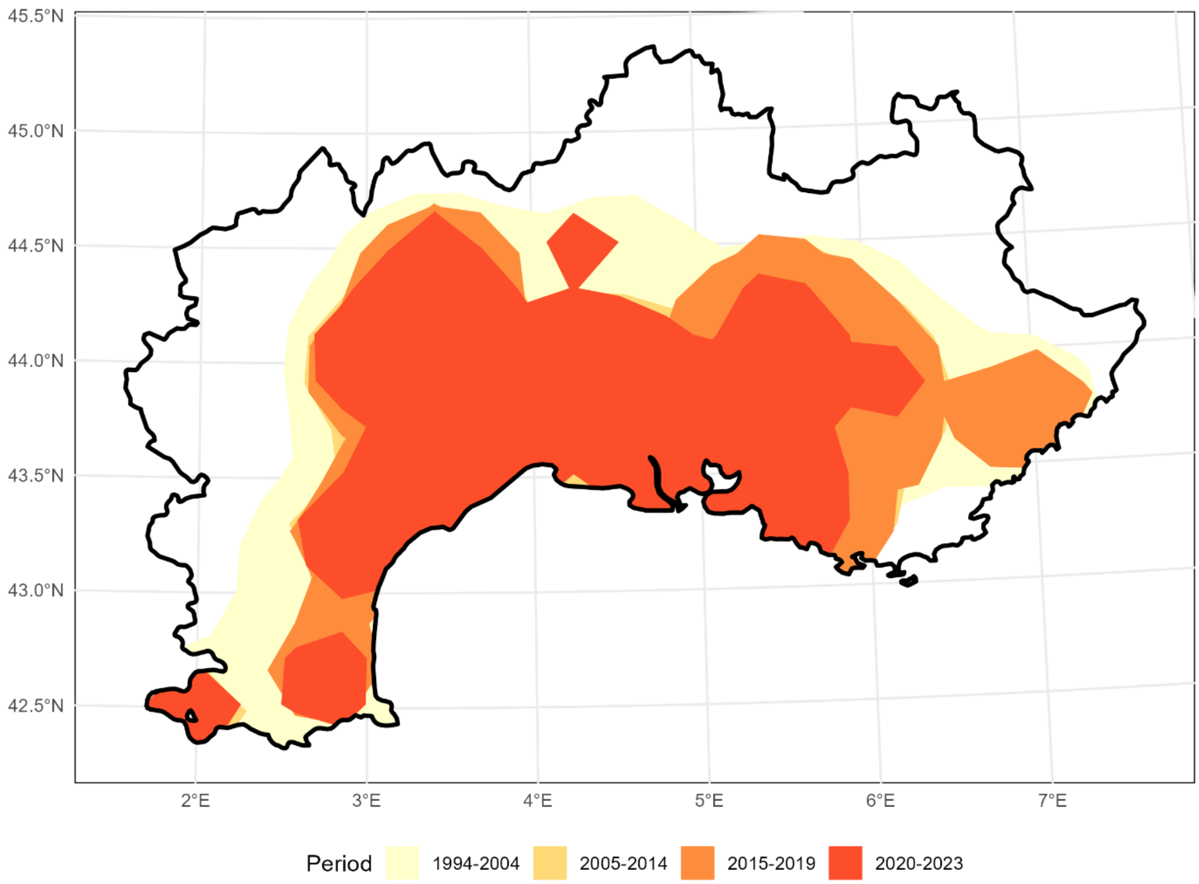


Figure 5: Temporal variation in the home range of the southern grey shrike (*Lanius meridionalis*) in southern France during four time periods between 1994 and 2023.

Clustering Analysis

During the most recent period, 2020-2023, a DBSCAN analysis based on the proximity of Southern Shrike sightings shows the presence of 18 distinct clusters in the study area (Figure 4). By marking isolated observations as noise, this technique indicates the fragmentation of the population into smaller groups, which tend to be more concentrated and closer together in the central part of the study area. At the same time, clusters are more dispersed in the map's southwestern (Catalan plain) and eastern (Provence-Alpes-Côte-d'Azur and Camargue) extremes.

Temporal Changes in Home Range

The calculated home ranges for each period show a notable decrease in areas over time. Using 1994-2004 as a reference period, the home range areas are smaller by **33.58%**, **30.93%**, and **47.24%** in the 2005-2014, 2015-2019, and 2020-2023 periods, respectively (Figure 5).

DISCUSSION

In this study, we examined the spatial distribution and density of breeding sites of the Iberian Grey Shrike in southern France, including their temporal changes between 1994 and 2023. Using kernel density estimation and DBSCAN clustering analysis, we could highlight spatial patterns of bird sightings and identify trends in spatial distribution and possible fragmentation within the population.

Interpretation of Results

The results of this study paint a complex picture of the ecological status of the Iberian Grey Shrike in France over the past 30 years. The increasing frequency of observations over time reflects not only the growing conservation efforts and availability of data collection tools but also the growing interest and involvement of ornithological enthusiasts and scientists and their increasing capability to monitor the species. Over the study periods, we observed significant shifts in the distribution and density of the Iberian Grey Shrike. The early period of 1994 to 2003 saw fewer recorded observations, likely due to the species' recent taxonomic reclassification, the unavailability of online data platforms, and a growing interest in avian monitoring (Isenmann & Bouchet 1993). As data collection platforms became more accessible and widely used from 2005 to 2014, there was a significant increase in reported sightings, reflecting the growing engagement by the birdwatching community, including citizen scientists.

The period from 2015 to 2023 is marked by the implementation of a French national action plan for Shrike conservation. This plan was accompanied by a systematic monitoring effort which resulted in numerous scientific field studies in a wide variety of locations. This, in turn, led to a surge in observations (Lefranc & Issa 2013). This uptick illustrates the effectiveness of structured conservation initiatives in promoting species monitoring.

However, despite the increased observational effort, growing environmental (climate change) and anthropogenic pressures on this species, and its paradoxical lack of spatial homogeneity, we found a significant reduction in the species' home range, nearly halving its distribution area between 1994 and 2023. In addition, despite more uniform spatial coverage by observers and more sightings in recent years (faune-france.org)(FIGURE 2), we found a marked clustering between 2020 and 2023. Populations become sparser and more fragmented, particularly in its range's south-western and eastern extremities, probably separating it permanently from more stable population strongholds on the Iberian Peninsula.

This could indicate ecological pressures, such as habitat loss, agricultural intensification, or climate change, leading to changes in habitat suitability and availability. The increased clustering, combined with a shrinking home range area, particularly post-2014, aligns with these potential pressures, signaling a reduction in suitable habitats or alterations in land-use patterns that could adversely affect the Shrike's ecological niche.

Comparison with Other Studies

Our findings are consistent with broader trends noted in avian populations across Europe. The observed distributional shifts in similar species are often attributed to the transformation of agricultural practices and urban expansion. For example, recent European studies indicated a substantial decline in native avifauna biodiversity, with a 17 to 19% decrease in the overall abundance of breeding birds since 1980, translating to a loss of 560 to 620 million individuals. Specifically, breeding birds in agricultural habitats have suffered a 35% reduction (Burns et al., 2021). Other studies have highlighted the devastating effects of agricultural processes on avian fauna in Europe (Rigal et al., 2023) or the detrimental impact of intensive practices such as the destruction of natural or semi-natural habitats and the effect of pesticides on bird populations (Donald et al., 2001; Hallmann et al., 2014; Moreau et al., 2022).

Ecological and Conservation Implications

The effectiveness of the French national action plan in increasing observations underscores the value of such programs, suggesting that continuous support and funding for these initiatives is pivotal.

Furthermore, the reduction in home range size calls for a reassessment of current habitat management practices. Given this species specific habitat requirements, maintaining a diverse and connected landscape is critical for conserving it. Conservation efforts must be dynamic and should evolve with the changing ecological landscape and species' needs.

Limitations of the Study

Data collection depends on the participation of both amateur and professional naturalists, which could introduce a bias towards more accessible or well-known areas, leading to under-sampling of specific areas. Furthermore, the reliance on observational data means that actual population sizes may not be fully represented, as detection rates can vary with observer skill, effort, and environmental conditions. The spatial resolution of the data also poses constraints on detecting finer-scale habitat preferences and species interactions.

Further Research

Further research should mitigate these limitations by integrating more systematic approaches to conduct surveys, such as point counts or transect surveys, which can provide more standardized data. Remote sensing technologies and habitat modeling could also be employed to understand habitat changes over time better. Collaborations with local conservation organizations might enhance data collection and ensure more consistent monitoring efforts across the Shrike's range. Interdisciplinary studies combining ecological, genetic, and behavioural research would contribute to a more holistic understanding of the species conservation needs.

Acknowledgements

Editorial assistance, in the form of language editing and correction, was provided by XpertScientific Editing and Consulting Services.

Conflicts of Interest

None to declare

References

Equipa Atlas. 2022. III Atlas das Aves Nidificantes de Portugal (2016-2021). SPEA, ICNF, LabOr/UÉ, IFCN. Portugal. https://www.listavermelhadasaves.pt/atlas/lanius-meridionalis/

BirdLife International. 2021. *Lanius meridionalis (Europe assessment). The IUCN Red List of Threatened Species* 2021: e.T22729533A200216423. https://dx.doi.org/10.2305/IUCN.UK.2021-3.RLTS.T22729533A200216423.en. Accessed on 16 January 2024.

Burns, F., Eaton, M. A., Burfield, I. J., Klvaňová, A., Šilarová, E., Staneva, A., & Gregory, R. D. 2021. Abundance decline in the avifauna of the European Union reveals cross-continental similarities in biodiversity change. Ecology and Evolution, 11, 16647–16660. https://doi.org/10.1002/ece3.8282

Donald P. F., Gree R. E. & Heath M. F. 2001. Agricultural intensification and the collapse of Europe's farmland bird populations. *Proc. R. Soc. Lond. B.* **268**(1462):25-29. https://doi.org/10.1098/rspb.2000.1325

Equipa Atlas. 2022. III Atlas das Aves Nidificantes de Portugal. 2016-2021. SPEA, ICNF, LabOr/UÉ, IFCN. Portugal. https://www.listavermelhadasaves.pt/atlas/lanius-meridionalis/

Ester, M., Kriegel, H. P., Sander, J., & Xu, X. 1996. A density-based algorithm for discovering clusters in large spatial databases with noise. In KDD-96 Proceedings, 226-231. https://dl.acm.org/*doi/10.5555/3001460.3001507*

Hallmann C., Foppen R., Van Turnhout C. et al. 2014. Declines in insectivorous birds are associated with high neonicotinoid concentrations*.* *Nature* **511**:341-343. https://doi.org/10.1038/nature13531

Hameau, O., & Gilot, F. 2015. La Pie-grièche méridionale. In Issa, N., & Muller, Y. (Eds.), Atlas des oiseaux de France métropolitaine. Nidification et présence hivernale (p. 13). Delachaux et Niestlé, Paris.

Hameau, O., Alphand, M., Charbonneau, A., & Martin, C. 2019. Étude du territoire de reproduction de la Pie-grièche méridionale en garrigue. Faune-PACA Publication, 91, 13 pp. https://cdnfiles1.biolovision.net/www.faune-paca.org/userfiles/FPPubli/FPP91territoirePGMgarriguesV2.pdf

Hernández, A. M. (2020). Alcaudón real – *Lanius meridionalis*. In: Enciclopedia Virtual de los Vertebrados Españoles. López, P., Martín, J., Moreno-Rueda, G. (Eds.). Museo Nacional de Ciencias Naturales, Madrid. http://www.vertebradosibericos.org/

Hódar, J. A. 2006. Diet composition and prey choice of the southern grey shrike *Lanius meridionalis* L. in South-Eastern Spain: the importance of vertebrates in the diet. *Ardeola* **53**:237-249. https://api.semanticscholar.org/CorpusID:49227786

Isenmann, P., & Bouchet, M. A. 1993. L'aire de distribution et le statut taxonomique de la Pie-grièche grise méridionale *Lanius elegans meridionalis*. *Alauda* **61**:223-227. https://api.semanticscholar.org/CorpusID:132239640

Kie, J. G., Matthiopoulos, J., Fieberg, J., Powell, R. A., Cagnacci, F., Mitchell, M. S., Gaillard, J. M., & Moorcroft, P. R. 2010. The home-range concept: are traditional estimators still relevant with modern telemetry technology? *Phil. Trans. R. Soc. B* **365**(1550):2221-2231. https://doi.org/10.1098/rstb.2010.0093

Klassert, T. E., Hernández, M. A., Campos, F., Infante, O., Almeida, T., Suárez, N. M., Pestano, J., & Hernández, M. 2008. Mitochondrial DNA points to *Lanius meridionalis* as a polyphyletic species. *Mol. Phylogenet. Evol.* **47**(3):1227-1231. https://doi.org/10.1016/j.ympev.2008.03.012

Lefranc, N., & Issa, N. 2013. Plan national d'actions: Pies-grièches *Lanius spp*. 2014-2018. Ministère de l'Écologie, du Développement durable et de de l'Énergie. La Défense, France, 144 pp.

Lefranc, N., & Worfolk, T. 2022. Shrikes of the World. Bloomsbury Publishing, London, UK, 366 pp.

Lepley, M., Thevenot, M., Guillaume,C.P., Ponel, P. & Bayle, P. 2004. Diet of the nominate Southern Grey Shrike *Lanius meridionalis meridionalis* in the north of its range (Mediterranean France), Bird Study, 51:2, 156-162, DOI: 10.1080/00063650409461347

Moreau, J., Rabdeau, J., Badenhausser, I., Giraudeau, M., Sepp, T., Crépin, M., Gaffard, A., Bretagnolle, V., & Monceau, K. 2022. Pesticide impacts on avian species with special reference to farmland birds: a review. *Environ. Monit. Assess.* **194**(10):790. https://doi.org/10.1007/s10661-022-10394-0

Olsson, U., Alström, P., Svensson, L., Aliabadian, M., & Sundberg, P. 2010. The *Lanius excubitor* (Aves, Passeriformes) conundrum - Taxonomic dilemma when molecular and non-molecular data tell different stories. *Mol. Phylogenet. Evol.* **55**:347-357. https://doi.org/10.1016/j.ympev.2009.11.010

Poelstra, J. 2010. Trends in systematics. Speciation in shades of grey: the great grey shrike complex. *Dutch Birding* **32**(4):258-264. https://api.semanticscholar.org/CorpusID:195751670

Rigal, S., et al. 2023. Farmland practices are driving bird populations decline across Europe. *PNAS* **120**(21):e2216573120. https://doi.org/10.1073/pnas.2216573120

Seaman, D. E., & Powell, R. A. 1996. An Evaluation of the Accuracy of Kernel Density Estimators for Home Range Analysis. *Ecology* **77**:2075-2085. https://doi.org/10.2307/2265701

SEO/BirdLife. 2017. Programas de seguimiento y grupos de trabajo de SEO/BirdLife 2016. SEO/BirdLife. Madrid. https://seo.org/boletin/seguimiento/boletin/2016/html5forpc.html

Worton, B. J. 1989. Kernel Methods for Estimating the Utilization Distribution in Home-Range Studies. *Ecology* **70**:164-168. https://doi.org/10.2307/1938423

Yosef, R., ISWG International Shrike Working Group, C. J. Sharpe, J. S. Marks, & G. M. Kirwan 2020. Iberian Gray Shrike (*Lanius meridionalis*), version 1.0. In Birds of the World (J. del Hoyo, A. Elliott, J. Sargatal, D. A. Christie, & E. de Juana, eds.). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.ibgshr1.01

European Journal of Ecology, 2024, 116-121

CAMERA TRAPPING AS A MONITORING METHOD OF THE RED-BACKED SHRIKE (*LANIUS COLLURIO*) IN ITALY

Sauro Giannerini[1], Matteo Bianchi[2], Marica Furini[1], Lorenzo Nannelli[3],
Giulia Santalmasi[2]

[1]*Via Alberto La Rocca, 77, 58051 Magliano in Toscana, Grosseto, Italy; g.sauro@hotmail.it*
[2]*Oasi Dynamo, Via Privata San Vito 1 Località Piteglio, 51028 San Marcello Piteglio, Pistoia, Italy; info@oasidynamo.org*
[3]*Via Falciani, 20 E, 50023 Impruneta, Firenze, Italy; lorenzonannelli@gmail.com*

Abstract.

In Italian mountain areas, the recolonization of the meadows led by the forests is a factor that explains the decrease of some passerine birds, as well as the Red-Backed Shrike. The project aims to manage a meadow area of northern Apennine (Dynamo Oasis – Pistoia – Italy), testing a new method to monitor the species breeding population. Since 2019, we scheduled wintering shredding of meadows, keeping spontaneous shrubs in order to provide natural perches to Shrikes; at the same time, a study was carried out to monitor the breeding population of the species, collecting color-ringed data and resightings obtained through camera traps combined with artificial perches. The first four years of activity show that the species that mainly used the artificial perches was the Red Backed Shrike; the quality of collected images allows us to read the ring code and recognize the taxonomy of caught prey. Using the same data to evaluate the annual return rate and the distribution of the species along the study area, we considered both the ringing and photo-trapping one; overall, this last was the most representative. The first results obtained by the use of the camera traps led to remarkable results that may be useful for the conservation of the species, also linked to the use of the images for educational purposes, to raise awareness among the general public about the conservation of grasslands and of the Red Backed Shrike.

Key words: *Red-Backed Shrike, camera traps, color-ring banding, artificial perches*

Introduction

Wooded areas cover 38% of Italy and have increased by almost seven percent compared to 1990 in response to a transition process due to abandoned agricultural land by humans and environmental disasters, leading to forest regeneration (de Panizza, 2020). Passeriformes are considered bioindicators for changes in environmental biodiversity, particularly for changing agricultural landscapes. Many species related to mosaic landscapes, resulting from traditional agropastoral activities, are now rare, protected, and included in European laws. Red-backed Shrike (*Lanius collurio*, family Laniidae) is a predatory passerine that prefers open farm areas, surrounded by woods and fragmented by hedges and bushes; it has shown a demographic and distribution contraction because of the landscape changes. The Red-Backed Shrike is listed in the Annexes of the EU Birds Directive (EU 2009), emphasizing conservation responsibilities in the European Union. In mountain areas, the leading intensive agriculture, the abandonment of traditional mowing and grazing activities, with consequent invasion and colonization of grasslands by forests, has led to a remarkable loss of suitable habitats for the species and a consequent decrease of its presence (Casale and Pirocchi, 2005; Laiolo et al., 2004).

After implementing environment management plans in Italy, the Red-Backed Shrike has responded positively and the breeding population has increased in recent decades (Casale and Radames 2004; Brambilla et al., 2007). To implement effective conservation measures, a better understanding of its breeding biology, life history parameters, and population trends is crucial (Cox et al., 2014; Greenwood, 2007; Pedersen et al., 2018). Mapping and distance sampling methods are globally applied in bird survey techniques, including for shrikes (Gottschalk and Huettmann, 2011; Hidalgo et al., 2023). In recent years, using automated cameras to detect wildlife has become an essential tool for researchers worldwide. The last 20 years have also seen a marked improvement in automated cameras' reliability, portability, and technological advancement. Indeed, the use of camera traps has grown exponentially amongst researchers in more recent times, becoming a mainstream tool in conservation and ecology (Rowcliffe and Carbone, 2008). Camera traps provide multiple benefits, including unobtrusiveness, low cost, and the ability to conduct studies over large geographical scales and long observation periods, reducing survey efforts (Caravaggi et al., 2017; Chalmers et al., 2023). Camera traps also monitor secretive ground-dwelling birds (Znidersic, 2017).

Researchers have recently begun using camera traps to record perch visits, especially for raptors (Wong and Kross, 2018). Camera traps are also used to identify individual color-marked birds (Brides et al., 2018) or to record predatory birds in farmlands, collecting many pictures of shrikes (Hong et al., 2022). Performances about the combined use of artificial perch with camera traps have already been evaluated and confirmed, also within our study area, providing information about Red-backed Shrike diet composition (Giannerini et al. 2019; Giannerini et al. 2020); the same method was applied to the resighting of colored rings (Nannelli et al., 2021). In this paper, we aim to summarizing the results of camera-trap monitoring of Red-Backed Shrike and discuss the reliability of this method to estimate population parameters.

METHODS

We studied in the central Italian Apennines (Podere Nappo, Oasi Dynamo, Pistoia, Italy - 44.037205ºN, 10.797657ºE; 1100 m asl; about 10 ha). The area consists mainly of permanent meadows (30.7%) and woods with thorny shrubs (67.7%); 14% of the surface of both environments is occupied by Bracken Fern (*Pteridium aquilinum* (L.) Kuhn). Winter shredding of meadows is conducted once every four years to prevent forest regeneration; within this area, spontaneous shrubs with a buffer zone of 2 m are kept at distances of about 30 m from each other. We built a 2 m high artificial perch and a camera trap to monitor the Red-backed Shrike. Although several studies have used camera traps to record birds on perches, methods differ for target species, camera trap model used, or other specific needs (Hong et al., 2022). After several attempts involving different ways to set the camera trap and the perch (Giannerini et al. 2019), since 2019, both camera trap and perch have been installed on unique wooden supporting poles (Ø 8 cm). The perch (square wooden pole with a side of 3 cm) has a length of 30 cm. The structure for housing the camera trap consists of a solid iron "S" shaped section (1x1cm) fixed to the supporting pole with three screws. A stainless-steel angle bracket (2 mm thick) was screwed to the end of the profile, onto which the camera trap was installed with a ¼-inch screw with a UNC (Unified National Coarse) thread. The steel bracket allows minor position corrections during the alignment of the camera trap with the perch. In order to prevent birds from landing on the profile, thus collecting blurry images, we installed stainless-steel bollards for birds (Fig.1).

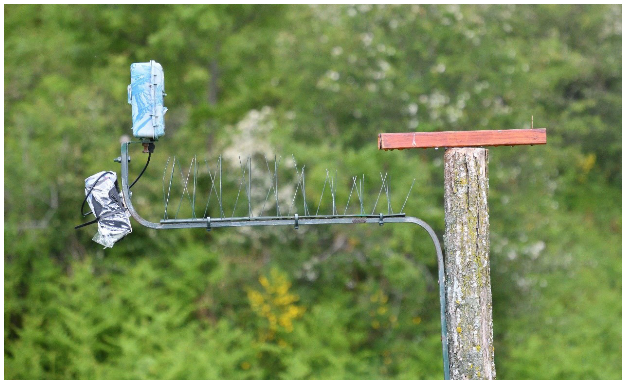


Figure 1. Artificial perch combined with a camera trap. In addition to the perch, the image shows the outer battery pack (6v) and stainless-steel bollards for birds to avoid landing outside the perch zone.

Because the distance between the camera trap and the birds on the perch is close, we contacted the dealer (Boly Media Communication Co. Ltd, 3235 Kifer Rd., Suite 260, Santa Clara, CA 95051, USA) to adjust the focal length to 50 cm. Although recent studies have shown that biased and imprecise results can be obtained when detection probabilities are low (Hofmeester et al. 2017; Kays et al. 2010), concerning the interaction between the probability of fast activation and camera trap model, the Scout Guard is one of the best camera traps that work on a short distance, especially with medium size birds (0-2.5 meters) (Palencia et al., 2022). The camera trap model was selected based on various parameters, including the angle of the detection zone (57°), focus distance (50 cm), sensor activation speed (<1 sec), and image quality (36MP), which allowed us to obtain sharp images even at multiple zoom levels. Perches were installed maintaining a consecutive distance between 58 m and 112 m; this sampling procedure ensures that each perch falls at least within a territory of Red-backed shrike couple. The average home range extension was considered to be about one hectare (Cramp and Perrins 1993; Brambilla et al. 2007), the minimum and average distance among nests equal to 58 m and 108 m, respectively (Paci et al. 2011), and the average distance between hunting perches and nest areas as 84.3 m (Meschini et al., 2011). Larger prey are often carried up to a perch before being killed and consumed (Cramp and Perrins, 1993; Lefranc, 2004), with maximum flights of 25 m for being captured in flight (Solari and Schudel, 1998). Artificial perches have been placed between 20 and 30 m from the ecotonal edge to limit the combined use of natural perches in the woods. Every year, were scheduled a ringing session during the first ten days of June to mark birds with colored rings. Red-Backed Shrikes captured were marked with both metal and colored rings (www.cr-birding.org/node/5127). Ornithologists and entomologists checked every collected photo. Collected data included perch identification number, date and time, bird species, age and sex, ring code, and taxonomy of captured prey (Figure 2).

Figure 2. Example of image collected by a camera trap. A colored engraved plastic plate provided the information on the perch identification number, and the date and time were automatically obtained by free software (Directory List & Print, Infonautics GmbH, Switzerland). The information on bird species, age and sex, ring code, and taxonomy of prey are evaluated by the ornithologist and entomologist.

Statistical analyses were conducted with the open-source R-studio program (Version 1.4.1564, Inc., Boston, Massachusetts) and used Chi-square comparison tests. Summarized results are presented as mean ± SD unless otherwise indicated. We calculated absolute and relative frequencies (in percentage) of perch use by each bird during the two study years. The hypothesis that the same individual used a single perch was tested to analyze the distribution of a breeding couple within the study area and the level of fidelity to the home range. The time series was shown based on ten-day periods (decades), from 11-20 May (decade 14) and 3-12 September (decade 25). The annual return rate was defined as the proportion of birds ringed in the previous year that returned to the same site the following year (Latta and Faaborg, 2001).

RESULTS

In the four study years, we captured and ringed 41 Red-Backed Shrikes (26 males, 15 females born before the calendar year of capture; year of birth unknown).

Between 2019 and 2022, from the 15th of May to the 15th of September, we obtained 70,270 camera events, showing 26 species from the camera traps. Red-Backed Shrike (94%) used the artificial perches the most. Only 0.10% of the images portrayed birds on the bollards set on the supporting pole, therefore at a distance that cannot guarantee a clear image. To show the use of perches by shrikes, we considered only the data concerning 2021 and 2022, when all the camera traps worked continuously. For the target species, 74.11% of pictures show adult males, 19.12% adult females, and 6.75% juveniles. Five percent of the pictures were until decade 18, 91% between decades 19 and 23, and 4% in decades 24 and 25. The absolute frequencies of pictures showed that males tend to use the perches to a lesser extent until decade 18 (6.7%), 92% between decades 19-23, and 1.3% in decade 24. No record was taken during decade 25. Females (1%) were detected until decade 18, 95% between decades 19-23, and 4% in decade 24; no record was taken during decade 25. Juveniles were recorded between decades 20 and 25 (Figure 3).

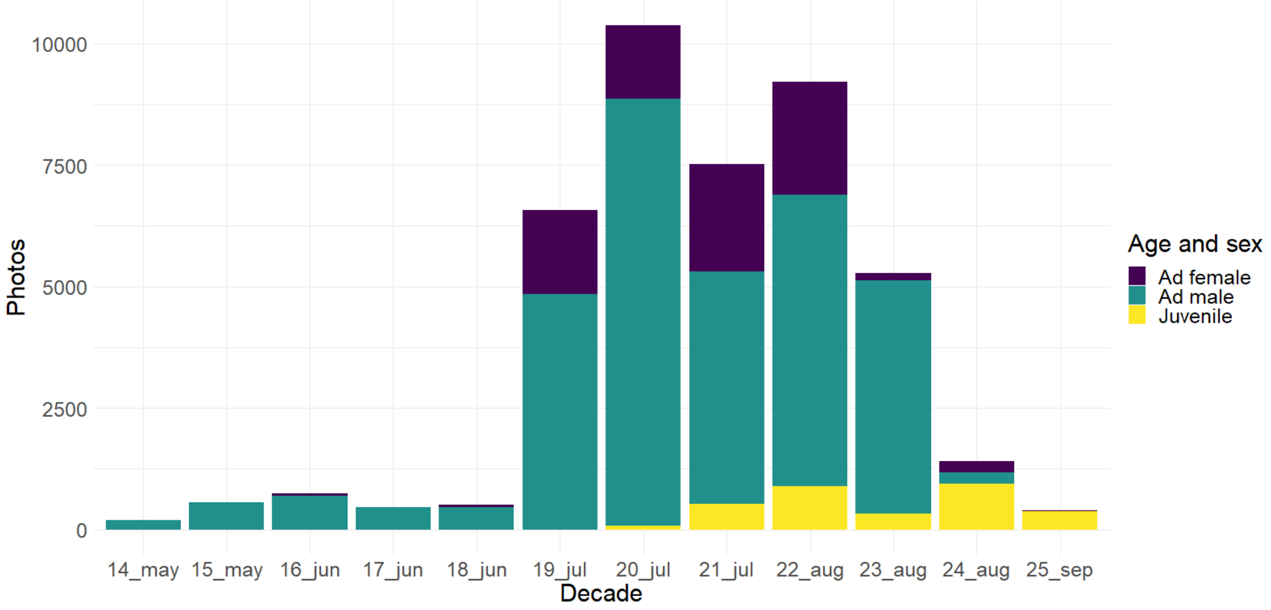


Figure 3.Absolute cumulative frequencies of pictures of Red-Backed Shrike obtained by camera traps mounted on artificial perches. This data concerns the last two years of monitoring (2021, 2022) and is divided by sex. Adult males comprised 74.11% of pictures, 19.12% of adult females, and 6.75% of juveniles. Five percent of pictures were until decade 18, 91% between decade 19 and 23, and 4% in decades 24 and 25.

Using the ringing and camera-trapping data, the return rate was 47.92% ± 8.24 for males and 32.11% ± 1.05 for females. Using only camera traps, the re-sighting rate was 62%. In 90% of the cases, each bird used a single perch, 48.14% exclusively, and 51.86% preferentially ($p>0.001$). The number of males that occupied the same perch was 3±0.43. Of the ten birds whose annual preferred perch was identified, five came back in subsequent years to the same perch (50%). Among all the images of the Red-Backed Shrike, it was possible to recognize the prey in 3,448 images, i.e., 4.9% of total. Over 96% of prey were insects: Orthoptera (41%), Coleoptera (12%), Hymenoptera (11%), Lepidoptera (4,3%), Diptera (1,6%), Hemiptera (0,3%), Dermaptera (0,2%), Heteroptera (0,1%), Mantodea (0,1%), Homoptera (0,1%), Mecoptera (0,1%), Neuroptera (0,1%), Odonata (0,1%), unidentified insects (25%); and 4% of the prey were Aranea.

Discussion and Conclusion

In the first four years of Red-Backed Shrike population monitoring in the Dynamo Oasis using colored rings, artificial perches, and camera traps, we obtained 70,270 images. The low percentage of the images on the bollards confirms that the perch design is adequate for the project. The perch dispersal in the study area provided a homogeneous sampling coverage in accordance with the biological pattern described in the literature, such as home range size during the breeding season and the distance between nest sites (Cramp and Perrins 1993; Brambilla et al., 2007; Paci et al., 2011). Our results showed that all the perches were used by Red-backed shrikes, confirming a continuous distribution of the species in the study area. Perch use, expressed by the number of pictures, increased from early July. This probably followed the intensification of food needed for fledglings, especially for females, who spent most of their time in the nest until late June. The range of each bird, identified by the color ring, was linked to a single perch in 46% of cases exclusively and in 54% of cases preferentially. This displayed a strong fidelity to the feeding site, probably related to the nest site, during the breeding season. The first data of interannual resighting shows a high fidelity to the breeding site. Perches used by more than one adult highlight the overlap of different home ranges. We checked the interannual site-fidelity in five males that returned to the territory occupied in the preceding year, suggesting probable fitness benefits. The initial results with camera traps have led to intriguing results, which can be helpful for species conservation. Concurrently, the images were also used for educational purposes, to raise awareness among the general public about the conservation of grasslands in general and of the Red-Backed Shrike in particular. Although increasing the number of perches requires more significant effort, this may increase the number of individuals at the study site (Yosef and Grubb 1994), their resightings, and better our knowledge of the species' biology. Our camera-trapping method can be used to optimize the perch density in managed habitats. So far an optimal density was documented in southern Belgium based upon classic observations during a limited time period of the breeding season (Van Nieuwenhuyse et al., 1995, Van Nieuwenhuyse, 1998). Research during all phases of the breeding cycle and in function of local landscape paramerters could be optimized with automatic data collection. Hence, combining camera-trapping with other classic methods, such as direct observation or radio-telemetry, would allow us to understand how effective and reliable the camera-trap data is in studying the biology of the Red-Backed Shrike.

Acknowledgment

The authors thank the Dynamo Oasis staff for having allowed the study. We also thank Dr. Emiliano Mori for the revision of the text. Further, we thank all friends and colleagues who have helped with the study.

References

Brambilla, M., Rubolini, D., Guidali, F., 2007. Between land abandonment and agricultural intensification: habitat preferences of Red-backed Shrikes *Lanius collurio* in low-intensity farming conditions. Bird Study 54, 160–167. https://doi.org/10.1080/00063650709461471

Brides, K., Middleton, J., Leighton, K., Grogan, A., 2018. The use of camera traps to identify individual colour-marked geese at a moulting site. Ringing & Migration 33, 19–22. https://doi.org/10.1080/03078698.2018.1525194

Caravaggi, A., Banks, P.B., Burton, A.C., Finlay, C.M.V., Haswell, P.M., Hayward, M.W., Rowcliffe, M.J., Wood, M.D., 2017. A review of camera trapping for conservation behaviour research. Remote Sens Ecol Conserv 3, 109–122. https://doi.org/10.1002/rse2.48

Casale, F., Pirocchi, P., 2005. La conservazione degli ambienti alpini nel Parco del Veglia Devero.

Casale, F., Radames, B., 2004. Gestione naturalistica di prati da sfalcio a favore di avifauna di interesse comunitario nel SIC e ZPS "Greto del torrente Toce da Domodossola a Villadossola." Presented at the Atti del Seminario permanente per la gestione delle praterie di interesse naturalistico, Quad. Parco Monte Barro, pp. 111–114.

Chalmers, C., Fergus, P., Wich, S., Longmore, S.N., Walsh, N.D., Stephens, P.A., Sutherland, C., Matthews, N., Mudde, J., Nuseibeh, A., 2023. Removing Human Bottlenecks in Bird Classification Using Camera Trap Images and Deep Learning. Remote Sensing 15, 2638. https://doi.org/10.3390/rs15102638

Cox, W.A., Thompson, F.R., Cox, A.S., Faaborg, J., 2014. Post-fledging survival in passerine birds and the value of post-fledging studies to conservation: Post-Fledging Survival in Passerines. Jour. Wild. Mgmt. 78, 183–193. https://doi.org/10.1002/jwmg.670

Cramp, S., Perrins, C.M., 1993. Handbook of the Birds of Europe, the Middle East and North Africa. The Bird of Western Paleartic. New York: Oxford University Press.

De Panizza, A., 2020. Rapporto sul Territorio 2020, 1st ed. Istat, IT.

Giannerini, S., Furini, M., Nannelli, L., Santalmasi, G., Chimera, G., 2019a. Miglioramenti strutturali del posatoio artificiale per il monitoraggio dell'Averla Piccola (*Lanius collurio*) con l'utilizzo di fototrappola. Presented at the XX Convegno Italiano di Ornitologia.

Giannerini, S., Furini, M., Nannelli, L., Santalmasi, G., Pezzi, M., 2019b. Posatoi artificiali abbinati a fototrappole: preferenze alimentari dell'averla piccola Lanius collurio. Gli Uccelli d'Italia 44, 21–28.

Giannerini, S., Nannelli, L., Bianchi, M., Lotti, C., 2020. Variazione stagionale nella dieta dell'Averla piccola Lanius collurio nell'Appennino settentrionale (Oasi Dynamo - Italia). Uccelli d'Italia 45, 15–24.

Gottschalk, T.K., Huettmann, F., 2011. Comparison of distance sampling and territory mapping methods for birds in four different habitats. J Ornithol 152, 421–429. https://doi.org/10.1007/s10336-010-0601-1

Greenwood, J.J.D., 2007. Citizens, science and bird conservation. J Ornithol 148, 77–124. https://doi.org/10.1007/s10336-007-0239-9

Hidalgo, J.C., Baonza, E., Bernal, I., Ortega, A., Talabante, C., 2023. The Red-backed Shrike (*Lanius collurio*) in the Central system of the Iberian Peninsula. https://doi.org/10.13140/RG.2.2.23468.64643

Hofmeester, T.R., Rowcliffe, J.M., Jansen, P.A., 2017. A simple method for estimating the effective detection distance of camera traps. Remote Sens Ecol Conserv 3, 81–89. https://doi.org/10.1002/rse2.25

Hong, S.-Y., Lin, H.-S., Huang, Z.-L., Choi, W.-S., Wang, W.-I., Sun, Y.-H., 2022. Perch-Mounted Camera Traps Record Predatory Birds in Farmland. Journal of Raptor Research 56. https://doi.org/10.3356/JRR-21-00001

Kays, R., Tilak, S., Kranstauber, B., Jansen, P.A., Carbone, C., Rowcliffe, M.J., Fountain, T., Eggert, J., He, Z., 2010. Monitoring wild animal communities with arrays of motion sensitive camera traps. https://doi.org/10.48550/ARXIV.1009.5718

Laiolo, P., Dondero, F., Ciliento, E., Rolando, A., 2004. Consequences of pastoral abandonment for the structure and diversity of the alpine avifauna. J Appl Ecology 41, 294–304. https://doi.org/10.1111/j.0021-8901.2004.00893.x

Latta, S.C., Faaborg, J., 2001. Winter Site Fidelity of Prairie Warblers in the Dominican Republic. The Condor 103, 455–468. https://doi.org/10.1093/condor/103.3.455

Lefranc, N., 2004. La Pie-grièche ecorcheur, Belin. ed.

Meschini, A., Scarfò, F., Quatrini, A., Simmi, F., Gregg, S., 2011. Modelli distributivi, uso dell'habitat riproduttivo e di foraggiamento dell'Averla piccola *Lanius collurio* alla riserva naturale del lago di Vico (central Italy). Presented at the XVI Convegno Italiano di Ornitologia, Cervia-Milano Marittima.

Nannelli, L., Ghinassi, G., Camilla, L., Bianchi, M., Furini, M., Giannerini, S., 2021. Breeding distribution pattern of Red-backed shrike (*Lanius collurio*) within a protected area (Dynamo Oasis - Italy): first results from camera traps resight. Gli Uccelli d'Italia 46, 19–26.

Paci, A.M., Casalini, R., Gaggi, A., 2011. Aspetti della biologia dell'Averla piccola *Lanius collurio* nell'Umbria settentrionale. Gli Uccelli d'Italia 36, 84–93.

Palencia, P., Vicente, J., Soriguer, R.C., Acevedo, P., 2022. Towards a best-practices guide for camera trapping: assessing differences among camera trap models and settings under field conditions. Journal of Zoology 316, 197–208. https://doi.org/10.1111/jzo.12945

Pedersen, L., Schnedler-Meyer, N.A., Ekberg, P., P. Tøttrup, A., 2018. Effects of forest management practices in clearings on breeding performance of the Red-backed Shrike (*Lanius collurio*). Ornis Fennica 95, 171–178.

Rowcliffe, J.M., Carbone, C., 2008. Surveys using camera traps: are we looking to a brighter future? Animal Conservation 11, 185–186. https://doi.org/10.1111/j.1469-1795.2008.00180.x

Solari, C., Schudel, H., 1998. Nahrungserwerb der Neuntöters *Lanius collurio* während der Fortpflanzungszeit. Orn. Beob. 85, 81–90.

Van Nieuwenhuyse D., 1998. Conservation opportunities for the Red-backed Shrike *Lanius collurio*. Shrikes of the World - II: Conservation Implementation. Proceedings of the Second International Shrike Symposium, Spring 1996, Eilat, Israel, ed. R. Yosef and F.E. Lohrer, IBCE Tech. Publ. 7: 79-82.

Van Nieuwenhuyse, D., Coussens, P. & Nollet, F., 1995. Digital method for recording and analyzing the territory use and activity budget of the Red-backed Shrike *Lanius collurio*. In Shrikes (Laniidae) of the world: biology and conservation. ed. R. Yosef and F.E. Lohrer, Proc. West Found. Vert. Zool. 6: 268-275.

Wong, E.L., Kross, S.M., 2018. Effects of Perch Location on Wintering Raptor Use of Artificial Perches in a California Vineyard. Journal of Raptor Research 52, 250–256. https://doi.org/10.3356/JRR-17-46.1

Yosef, R., T. C. Grubb, Jr. 1994. Resource dependence and territory size in Loggerhead Shrikes (*Lanius ludovicianus*). Auk 111:465-469.

Yosef, R., T. C. Grubb, Jr. 1994. Resource dependence and territory size in Loggerhead Shrikes (*Lanius ludovicianus*). Auk 111:465-469.

Znidersic, E., 2017. Camera Traps are an Effective Tool for Monitoring Lewin's Rail (*Lewinia pectoralis brachipus*). Waterbirds 40, 417–422. https://doi.org/10.1675/063.040.0414